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NEW NAMES ON OUR STAFF

Mr. Arthur G. Zander of Boys' Technical High School, Milwaukee, Wisconsin is now in charge of our Botany Department which has been without an editor since the death of Mr. Worrallo Whitney last March. Mr. Zander is a graduate of the University of Wisconsin in agriculture and biological science and has done graduate work in Marquette University. In addition to his many years as a teacher, he has had practical experience in the dairy manufacturing business and in agriculture development work in the territory served by the Great Northern Railroad. As an exponent of practical living botany, a highly successful teacher, a writer of ability, and an indefatigable worker he is well fitted for editorial work on the staff of a journal for science teachers. "The King of Plants," a play for science clubs which has been presented in many schools in all parts of the country, is one of his valuable contributions to this journal.

Heavy teaching loads, the demands of extra curricular activities and other necessary duties have robbed us of the valuable services of three other staff members: Mr. Harry A. Carpenter, Elementary Science Editor since this department was opened, Miss Katharine Ulrich, Editor for Geography since March, 1929, and Mr. Clarence Radius who inaugurated the Department of Science Demonstrations a year ago.

Dr. David W. Russell, Professor of Education and Assistant Director of the Demonstration School of the National College of Education, Evanston, Illinois will have charge of the Elementary Science Department. Professor Russell is a graduate of the University of Pennsylvania and a Ph.D. from Western Reserve

University. He holds important offices in a number of scientific and educational societies, is editor and contributor to texts in mathematics and science, and author of many articles in educational journals. With his leadership the further development of the Elementary Science Department is assured.

The Department of Science Demonstrations is now under the direction of Mr. William A. Porter, Head of the Science Department of Chisholm (Minn.) High School. Mr. Porter received his B.A. from Carroll College in 1925 and M.A. in 1933 at the University of Wisconsin where he has since continued work toward the doctorate in the summer sessions. Fourteen years in high school teaching the academic science courses and night school classes in practical radio and photography, and complete mastery of all the outdoor sports of the "Land-o-Lakes" have given him the resource and initiative to put up demonstrations for every occasion. Read his call to action below.

A PERSONAL MESSAGE TO TEACHERS OF SCIENCE

In taking over the work which has been so ably carried on in the past by Mr. Clarence Radius, I am fully aware that the success of this department depends solely on the cooperation that is secured from you who teach in the field. No doubt, each of you has during your experience developed procedures, techniques and demonstrations which assist you in the presentation of your work. Much of this valuable material is never published with a consequent loss to the progress and interest of science teaching. Therefore I urge each of you to write up your favorite scheme or teaching device and send it to me. Those articles suitable for publication and of interest to the majority of teachers will be published so that others may profit by your experience and you may receive recognition for your contribution. Let's hear from you soon!

WILLIAM A. PORTER

LONG-LOST BUOY

A buoy, adrift in the Arctic Ocean for 36 years, has been found on the northwest coast of Novya Zemlya, Tass reports. Marks on it indicate that it was part of the equipment of the American Baldwin-Ziegler expedition, and was put overboard in 1902. It will be sent to the Leningrad Arctic Institute.

THE ROLE OF HORMONES IN REPRODUCTION*

By H. O. Burdick
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The field of endocrinology has grown so rapidly in the last few years that it is difficult to keep informed on all the experimental work and to understand the increasingly perplexing terminology. The purpose of this paper is to present some of the pertinent facts and theories concerning the functions of hormones in reproduction. No attempt will be made to include a list of the host of workers in this field who have made possible our present knowledge, but a bibliography of some of the outstanding books on the subject will be appended.

The ovary is the egg producer. Eggs continually develop within the ovary of immature females but these are never expelled from the body of the ovary; they are resorbed. The release of eggs from the ovary of the mature individual is subject to the control of pituitary gland endocrines. The pituitary, or hypophysis rests in a bony socket on the ventral surface of the brain and is composed of an anterior pituitary lobe (A.P.) and a posterior lobe (P.P.) joined by a tissue isthmus. This gland is small but indispensable because it produces several important hormones. One hormone secreted by the anterior pituitary acts upon the reproductive tract causing this region to become sexually mature. This is known as a gonadotropic factor, or better, the *follicle-stimulating hormone* (FSH) because of its effect on the ovary. Examination of a cross section of a mammalian ovary will show many various-sized spheres, the Graafian follicles, within each one of which is an immature egg. The follicle-stimulating hormone of the anterior pituitary causes at least one of these follicles to enlarge and fill with follicular liquor and at the same time brings about the maturation of the enclosed egg.

The ovary, under the influence of FSH is stimulated to manufacture and secrete a chemical of its own which is called the *estrogenic* hormone. Bio-assays of the follicular liquor have yielded a substance which is now termed *estradiol* (di-hydroxyestrin). Much confusion has arisen because commercial houses marketing hormones have each used a different trade name for

* The author wishes to express his appreciation to his research assistant, Miss Rae Whitney, for the diagrams used in this paper.

its own particular estrogen. (See list of trade names at the end of this paper.) Furthermore, these commercial estrogens are largely extracted from the urine of pregnant animals, which source yields a substance that differs chemically from estradiol. The urine extract is known bio-chemically as *estrone* (keto-hydroxy-estrin). Estradiol and estrone are both estrogens in that they both produce, in the female laboratory animals, definite anatomical and physiological changes which make mating possible. While *(o)estrin* is commonly used as a general term to include all estrogens whether they be from the ovary, urine, placenta or produced synthetically in the laboratory, *estrogen* will be the term used throughout this discussion. Probably in future literature on this subject the term estrogen will be substituted for estrin. The name estrin is derived from oestrus which is the term applied to the period when lower mammals will mate. The adjective (o)estrous is frequently confused with the noun (o)estrus. The estrous cycle of lower mammals is not homologous to the menstrual cycle of primates as will be shown later.

In the normal ovarian cycle, estrogen is secreted by the ovary and while most of it is thrown off into the blood stream, some is stored in the enlarging Graafian follicle. Apparently the follicle-stimulating hormone (FSH) alone, in primates, is not capable of causing the rupture of the Graafian follicle. Recent experiments tend to prove that an increase of estrogen in the blood reaching the anterior pituitary inhibits the production of more of the follicle-stimulating hormone and causes the secretion of a second anterior pituitary chemical known as the *luteinizing hormone* (LH), which, passing to the ovary via the blood stream, brings about the final maturation of the ovum and causes the rupture of the thin outer wall of the distended follicle thus liberating the unfertilized ovum. This process, the escape of the egg from the ovary, is termed ovulation. The antagonistic action of estrogen on the pituitary cells producing FSH is a natural safeguard to prevent an unnecessary number of eggs being thrown off in any one cycle. While usually only one egg is fully matured during each cycle in humans, superovulation can and does occur! The mouse normally ovulates five to eight eggs each cycle but superovulation of 30 or more eggs can be brought about experimentally by the injections of proper amounts of the anterior pituitary hormones. Much confusion has arisen because earlier literature and some recent text-

books have used the terms *prolan* A or Rho I for the FSH and *prolan* B or Rho II for the LH. The present tendency is to use the terms prolan A and prolan B when the urine and not the pituitary is the source of these extracts. The physiological properties of the urine prolans seem to differ somewhat from those of FSH and LH extracted directly from the pituitary.

Estrogen has another important function in that it helps to prepare the uterus to receive the egg. Before ovulation, estrogen secreted into the blood stream stimulates the mucosal lining (endometrium) of the uterus to grow and thicken until the uterus becomes considerably ballooned. Non-secreting glands appear in the endometrium. Either estradiol or estrone, when injected into an immature rat, will not only produce these typical uterine changes but will also hasten the sexual maturity of the animal to make mating possible at 45 days of age instead of the usual 65 to 70 days.

Even though estrogen has stimulated the growth of the endometrium of the uterus, the developing embryo cannot become implanted on the uterine wall until another hormone has had its effect. When the follicle in the ovary ruptures and expels an ovum, the remaining cavity is filled first with a blood clot (corpus hemorrhagicum), then with scar tissue known as the corpus luteum (which by derivation means "yellow body" but which is actually pinkish in some animals). This growth of scar tissue is made possible by the luteinizing hormone (LH). Without LH little or no luteal tissue develops whereas the injection of an excess of LH will often cause such a rapid growth of corpus luteal cells in the Graafian follicles that the eggs are imprisoned therein. This is often true in pregnancy tests which will be discussed later. It is now certain that the hormone from the corpus luteum stimulates the final development of secreting glands in the thickened endometrium of the uterus and this tissue thereafter has a rather ragged appearance. The name given this hormone is progestin or progesterone which means "before gestation." The uterus or "nest" is now ready for the fertilized egg. It should be remembered that in the preparation of the uterus each factor is properly timed and those hormones appearing later in the series cannot function unless the proper physiological sequence has been followed. For instance, progesterone will not cause the glandular development within the uterus unless that organ has been previously acted upon or primed by estrogen. Nor will estrogen alone prepare the uterus.

A summary of the material presented thus far:

1. The *follicle-stimulating hormone* (FSH) of the anterior pituitary stimulates follicular development and estrogen production in the ovary.
2. *Estrogen* (estradiol) secreted by the ovary:
   a) inhibits further FSH production,
   b) stimulates the growth of uterine endometrium and unbranched, non-secreting glands,
   c) activates the pituitary to form the luteinizing hormone (LH).
3. The *luteinizing hormone* (LH) of the anterior pituitary:
   a) brings about the final maturation and rupture of the follicle,
   b) stimulates the corpus luteum formation.
4. The corpus luteum hormone, *progesterone*, causes uterine gland growth and secretion resulting in a uterus which is only then ready for the egg.

Although the changes in the uterine cycle are dependent upon both estrogen and progesterone in proper sequence, there is however, an apparent antagonistic action between the two substances. It has been shown experimentally that an excess of estrogen in some of the laboratory mammals overrides the progesterone action on the endometrium of the uterus. This prevents implantation of the ovum and subsequent pregnancy.

In primates, if the ovum is not fertilized, the uterine lining degenerates and sloughs off about two weeks later. This sloughing, accompanied by more or less bleeding, is known as menstruation and normally lasts from three to five days. Just what chemical factors are responsible for this degeneration have not been fully determined, but the lowered level of estrogen in the blood and the cessation of corpus luteum secretion are causes most frequently mentioned. Since the egg was not fertilized the corpus luteum of ovulation does not develop into a corpus luteum of pregnancy but becomes whiter in color and is now called the corpus albicans. The secretion of progesterone stops and the corpus albicans is gradually resorbed by ovarian tissues. There is good reason to believe that the presence of the hormone from the corpus luteum has also inhibited the production of FSH of the anterior pituitary. When the chemical influence of the corpus luteum ceases, the pituitary again begins to secrete FSH. The presence of fresh FSH in the blood stimulates the growth of a new follicle in the ovary. Thus a new ovarian or menstrual cycle is initiated.

It is essential to know that menstruation of primates is not the same as estrus, the mating or "heat" period in lower mammals. Menstruation marks the end of an ovarian cycle and is evidence that the human egg was not fertilized. Ovulation in humans probably takes place about the middle of the ovarian cycle. Counting the first day of bleeding as the first day of the new

ovarian cycle, then ovulation usually occurs 8 to 16 days later. These cycles vary considerably in length in different women and even in the same individual. Ovulation probably takes place earlier in the 21-day cycle and later in a 35-day period. In humans, mating may take place at any time during the cycle, but the egg is fertilized only when mating occurs reasonably close to the time the egg leaves the ovary and reaches the upper end of the fallopian tube. Lower mammals normally mate at the time of estrus or heat, that is, when the female is stimulated by the influence of an increase of estrogen in the body. Only at this time is the female of lower animals receptive to the attention of the male. Ovulation occurs either about the time of mating or within a few hours afterwards. A simple diagram summarizes these statements.

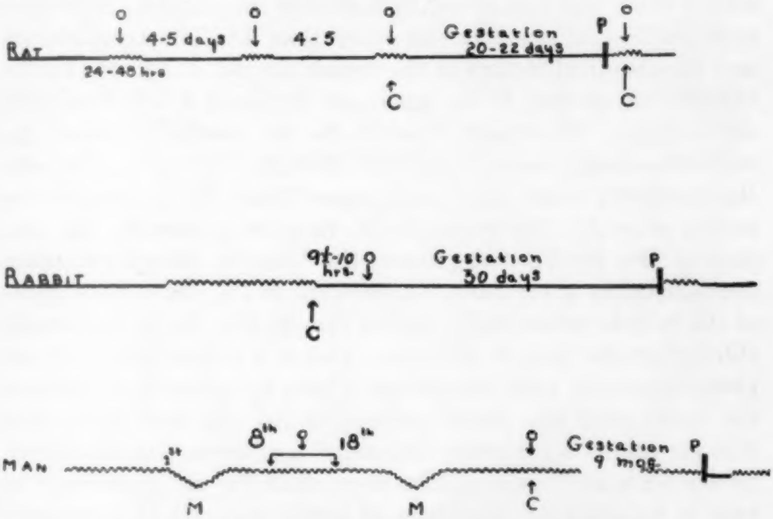

FIG. 1. Comparison of mating activity in rat, rabbit and man.
O—ovulation
C—coitus
P—parturition
M—menstruation
-—period during which female will not mate
~—period during which female will receive male

It is interesting to note that ovulation in the rabbit, cat and ferret occurs only after the stimulus of mating. In most mammals, however, the ovum is discharged as a regular cyclic phenomenon in the pituitary-ovarian cycle. This is probably true in humans. The relative sterility of the pre- and post-ovulatory periods has aroused much discussion about "safe (sterile)

periods" for pregnancy prevention. Whether there is an increase in libido or mating urge in humans at the time of ovulation, comparable to that at estrus in lower mammals, is a matter not yet settled for many psychological factors are involved and there is a lack of case histories from intelligent women.

After the egg is discharged from the ovary it comes to rest in the upper end of the fallopian tube. If spermatozoa are present or make their way there within a few hours, fertilization will probably occur. More and more evidence is accumulating to show that the mammalian ovum remains fertilizable for only a few hours. Even the sperm cells have a much more limited life in the female reproductive tract than was formerly supposed. Whereas it was once thought that sperms were capable of fertilizing the egg after remaining for days, even weeks, in the female tract, it is now generally held that this capacity is limited to a few hours, possibly not more than 48. The temperature and the chemical factors in the female are not conducive to the viability of sperms. If the egg is not fertilized it will gradually disintegrate. All evidence points to the conclusion that the unfertilized egg does not pass out through the vagina. Dissolution probably takes place as it passes down the oviduct to the uterus or within the uterus itself. In most mammals, the passage of the fertilized egg down the tube to the uterus takes approximately three days. The descent in the upper two-thirds of the tube is rather rapid so that the egg may be in the uterine third after the first 24–36 hours. This is a remarkably uniform phenomenon in most mammals. There is evidence to support the belief that this tubal passage of the egg and its descent into the uterus is under the control of hormones. Recent experiments with mice and rabbits show that the tubal passage of eggs is retarded by injections of small amounts of estrogenic hormones but accelerated by massive injections of the same substance. The eggs will degenerate rapidly if held in the tubes a day or two beyond the usual limit and likewise, the "accelerated" ova usually disintegrate. Thus conception is prevented by a temporary hormonal sterilization. Under normal conditions, the fertilized eggs have been going through regular cell divisions during the tubal descent. In the mouse and rabbit the eggs reach the morula stage (about 32 cells) or else the early blastula stage as they enter the uterus. The eggs are not immediately implanted on the uterine wall but remain floating in the uterine fluid for three to five days more while they rapidly increase in

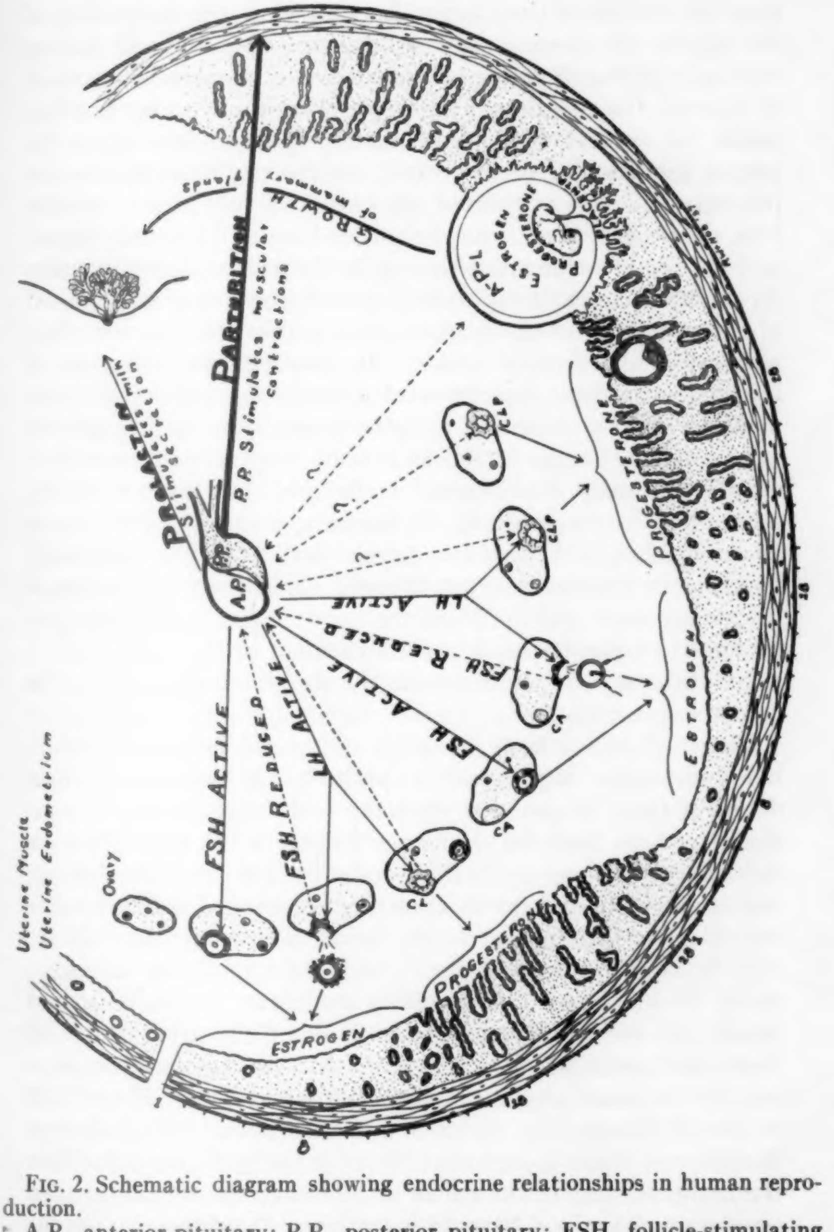

FIG. 2. Schematic diagram showing endocrine relationships in human reproduction.

A.P., anterior pituitary; P.P., posterior pituitary; FSH, follicle-stimulating hormone; LH, luteinizing hormone; CL, corpus luteum; CA, corpus albicans; CLP, corpus luteum of pregnancy; APL, anterior pituitary-like hormone of the placenta.

size. The length of time before implantation, the imbedding of the egg in the uterine mucosa, depends upon several factors such as suckling of young or the species of mammal concerned. In the rat, the suckling of a litter of young may delay implantation for several days. Implantation is dependent upon the proper conditioning of the uterus for the egg by estrogen and progesterone as was pointed out earlier in this paper. In rabbits, the progesterone from the corpus luteum is not only necessary for the attachment of the egg to the uterine lining but also for maintaining early embryonic growth since surgical removal of the ovaries or of the corpora lutea within the first few days will cause abortion in rabbits. If, however, progesterone is injected into these experimental animals the embryonic connections will be preserved and the young may be brought to full term. The corpus luteum of rabbits is apparently necessary only in the early development as the placenta takes over the production of progesterone. In humans, its presence may not be essential after the first few days of early embryonic development for its removal has not brought about the termination of pregnancy as in rabbits. Nevertheless the extract of the corpus luteum is frequently used in the treatment of threatened abortion. This may simply augment the progesterone supply of a defective placenta.

There is such a large quantity of several hormones in the blood and urine of pregnant animals that it seems more than doubtful that the anterior pituitary and ovary alone can produce so much material. Evidence points to the placenta as a rich source of these endocrine products. The Ascheim-Zondek test for pregnancy depends upon the presence of *anterior-pituitary-like* (A-P-L) factors in the urine. These are the follicle-stimulating hormone, *prolan* A and the luteinizing hormone, *prolan* B. The latter is particularly abundant. As was indicated before, the term prolan is used to indicate the urine source of these substances which experiments thus far show do not have exactly the same physiological properties as the FSH and LH of the pituitary. The common modification of the Ascheim-Zondek test is the injection of 10 cc. of the patient's urine into the marginal vein in the ear of an unmated female rabbit; the ovaries are examined 10 to 24 hours later. If evidence of ovulation is found, or if ovarian hemorrhage areas have been formed, it is concluded that a pregnant condition exists in the woman. Absence of such changes in the ovaries indicates a non-pregnant condition. This test is more than 95 per cent certain and may be

used to advantage any time after the first "missed" menstrual period. One group of investigators has shown that the placenta and not the embryo is the source of hormones which are necessary for maintaining later stages of pregnancy in rats. In this experiment the embryos were removed from their fetal envelopes within the uterus but the placentas were left undisturbed. The residual tissues were carried to full term and delivered as usual.

If the human uterus does contain a product of conception there follows an embryonic and foetal growth for approximately nine months with, normally, freedom from menstrual bleeding. During this period the quantities and balance of hormones in the blood stream change. What all these changes mean is not yet known. In addition to these there are interrelationships between the pituitary, ovary, placenta, thyroid and adrenal glands but only a few of these correlations have been determined. Meanwhile, the mammary glands increase in size and glandular content, but are not yet ready to secrete. This development is probably due to a proper balance and sequence of estrogen and progesterone from either the placenta or the ovary, or both. Recent studies indicate the necessity of the presence of the pituitary in the development of the breasts. If estrogen (sometimes with progesterone) is injected into females of some of the lower mammals, the mammary glands enlarge although the animals are not pregnant. If the pituitary is removed before such injections there is no growth response in the breast tissue. Under normal conditions the mammary glands do not secrete milk until several hours after birth when a special anterior pituitary hormone, ***prolactin***, is secreted which stimulates the glands to produce milk. Excess estrogen inhibits lactation.

Not all of the chemical factors in the physiology of labor have been determined but much of the process is now understood. The posterior lobe of the pituitary is apparently the chief factor at this stage. At the end of the nine-month period in humans the blood-estrogen level has been markedly reduced but the significance of this reduction is not fully understood. The posterior pituitary begins to secrete a chemical, known as ***pituitrin***, which induces contractions of the uterine muscles. These gentle contractions of labor are at first more or less widely spaced in time. However, they increase in frequency and intensity until, aided by expulsive efforts of the patient, the child is born. Soon after this, further contractions loosen the foetal envelope and crowd it out of the uterus.

While it would seem that much is known these days about hormones in normal reproduction a great deal is still to be learned about the control and the interrelationships of the endocrine glands. The clinician is faced with problems of the causes and correction of endocrine maladjustments which so frequently occur. Many perplexing questions arise: which hormone should be used, what dosage, how often and when in the cycle; what will be the effect upon other parts of the body; is the effect temporary or permanent. These and many other questions concerning the role of hormones in reproduction will be answered sometime by the combined efforts of the clinician, the biochemist and the experimental physiologist.

TABLE I. SOME SCIENTIFIC AND COMMERCIAL NAMES OF HORMONES ASSOCIATED WITH REPRODUCTION IN MAMMALS

(Trade names follow the Arabic numbers)

I. **Estrogens**—Estrus-producing (estrogenic) hormones from the ovary, obtained largely from the urine of pregnant mammals. The term (o)estrin is still commonly used to include any and all estrus-producing hormones.

A. **Estrone** (keto-hydroxy-estrin). Source: urine of pregnant animals.
1. Amniotin
2. Folliculin
3. Menformon
4. Progynon
5. Theelin

B. **Estriol** (tri-hydroxy-estrin). Source: urine of pregnant women and human placenta.
1. Emmenin
2. Theelol

C. **Estradiol** (di-hydroxy-estrin). Probably the true follicular liquor.
1. Di-hydro-folliculin
2. Di-hydro theelin
3. Progynon-B (estradiol benzoate)
4. Progynon-DH

II. **Progesterone**—the corpus luteum hormone.
1. Lipo-lutin
2. Progestin
3. Prolution (synthesized from soy bean oil)

III. **Gonadotropic** (ovary-stimulating). Hormones from the anterior pituitary and placenta but mostly from pregnancy urine.
1. Antophysin
2. Antuitrin-S
3. Follutein
4. Hebin
5. Phyone
6. Polyphysin
7. Prephysin

IV. **Lactogenic** (milk-producing). Hormone of the anterior pituitary.
   1. Prolactin

V. **Post Pituitary Hormone.** Causing uterine contractions.
   1. Pituitrin
   2. Pitocin

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LUNG CANCER DUE TO TOBACCO SMOKE

More persons are dying of cancer of the lung than ever before, probably because more persons are smoking and inhaling tobacco smoke than ever before. This startling statement was made by Drs. Alton Ochsner and Michael De Bakey of Tulane University School of Medicine, New Orleans, at the cancer symposium at New York.

"The inhaled smoke, constantly repeated over a long period of time, undoubtedly is a source of irritation" to the lining of the bronchial tubes, the New Orleans surgeons gave as their opinion.

Ten to fifteen out of every 100 primary cancers, not those that have spread from other cancers elsewhere, are lung cancers, they stated. Lung cancer is found in one or two out of every 100 persons examined after death.

Persistent cough with expectoration, bloody sputum and discomfort in the chest, are the most prominent symptoms, and in any one past 40 years of age should be considered signs of cancer until proved otherwise.

The only hope of cure is to remove the entire lung and the lymph nodes in the chest. This has been done in 87 patients, eight of them operated on by the New Orleans surgeons. Of their eight patients, three survived. One is still living two and one-half years after the operation. The others were only recently operated. Of the 79 other patients, 50 died and 29 recovered.

EXPERIMENTS WITH A MIRROR OF VARIABLE CURVATURE

By W. V. Burg
University of Toledo, Toledo, Ohio

It is customary in courses of elementary physics to show the geometrical properties of mirrors by means of experiments that employ plane, convex and concave mirrors of fixed curvature. Though this method has merits that are not to be questioned, it can—according to the author's experience—be supplemented very successfully by some experiments with a properly constructed flexible mirror. The important advantage of such a device is that it enables the students to observe the gradual change of the curvature of a mirror and the consequent change of its optical properties. It is the aim of this article to call attention to a simple and inexpensive apparatus that has proved to be very satisfactory for the purposes just mentioned.*

As is seen from the accompanying picture, the apparatus (Fig. 1) consists of the following parts: the mirror, which is a highly polished, rectangular sheet of flexible metal; the device for altering the curvature of the mirror; and the wooden board which supports the mirror and accessories and which also serves to render the incident and the reflected rays visible. The sheet of metal, which is held in a position perpendicular to the board, is sufficiently near the latter that no light will pass behind the reflecting surface. The center of the mirror is supported by a horizontal guiding rod, while its upper and lower edges are held between small cylindrical tubes that are inserted in the board at right angles. Two tiny pins, which are soldered to the mirror near the edges, just touch those tubes when the curvature has reached the limit for satisfactory reflection. This arrangement not only keeps the mirror in its position between the tubes but also sets a definite maximum value for its curvature, which value is the same whether the shape is convex or concave. The mirror is connected to the guiding rod by means of a small round plate which forms one end of the rod and turns freely in a little case that is soldered to the back of the sheet of metal. The other end of the rod carries a small knob for turning the rod

* A device frequently employed in courses of experimental optics consists of a series of small plates of reflecting material that are connected in such a manner as to produce a crude imitation of a flexible mirror. Such an instrument, however, is not completely satisfactory for experiments of the kind discussed here.

in order to change the curvature of the mirror. The part of the rod farthest away from the mirror is provided with a fine screw-thread. A small piece of wood fastened to the board carries a hollow cylinder of metal that serves as the screw nut and also helps to keep the rod exactly parallel to the board. This position is further assured by a second similar guide that is placed nearer to the mirror. In order to make the light rays that graze the board more clearly visible, it is covered with white paper or the

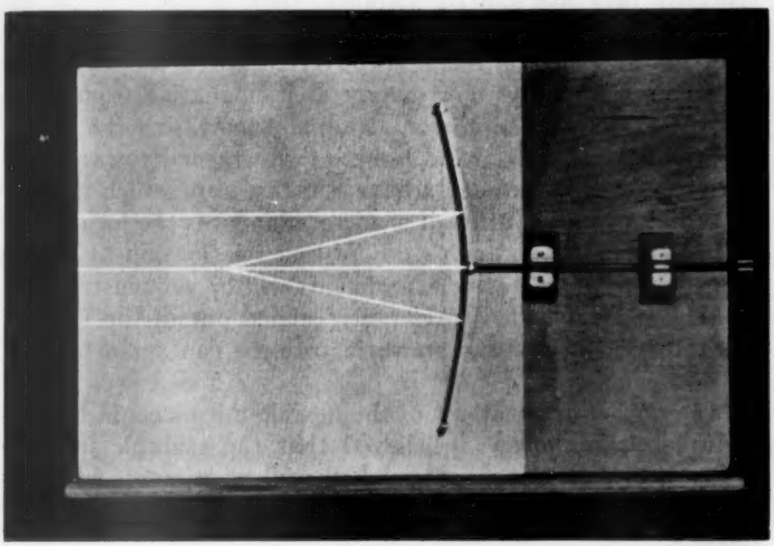


Fig. 1

like. On this surface a few typical positions of the mirror may be indicated.

The practical application of the apparatus is so simple that no detailed description will be needed. By turning the knob the curvature of the mirror is gradually changed in one or the other direction. As long as the sheet of metal is not bent too much, its central portion will reflect the incident rays in a manner that is very satisfactory for all practical purposes.

The apparatus is a useful instrument for both lecture and laboratory. Many of the demonstrations and exercises ordinarily carried out with mirrors of fixed curvature may be performed successfully with this apparatus. However, its real province is those experiments which involve a change of the curvature. A typical example is the demonstration of the relationship be-

tween the curvature of a mirror and the location of its focus. The procedure is as follows: By turning the guiding rod in the proper direction the sheet of metal is bent so that a concave mirror of relatively large curvature results. An incident pencil of parallel light is reflected so as to converge at a point close to the mirror. The curvature of the mirror is now gradually decreased, which causes the point of convergence to migrate away from the mirror until, when the latter has become plane, the reflected rays are exactly parallel, that is converge at infinity. On turning the guiding rod a little further in the same direction, the sheet of metal is converted into a convex mirror and the reflected rays now diverge as if emanating from a distant point behind the mirror. Gradually increasing the curvature moves the imaginary point of divergence towards the mirror.—After the students have, thus, seen in which manner a change of the curvature of a mirror influences the location of its focus, a more thorough study of that relationship by means of a series of quantitative experiments will be very instructive. In this study, which is preferably carried out in the form of laboratory exercises, the above instrument can again be used with full success.

Many other applications of the flexible mirror could be enumerated; it is, however, believed that the example just described will show clearly enough how well experiments with this apparatus fit into the program of a course on elementary physics.

AN ANNOTATED LIST OF BOOKS RECOMMENDED FOR THE SECONDARY SCHOOL PHYSICS LIBRARY

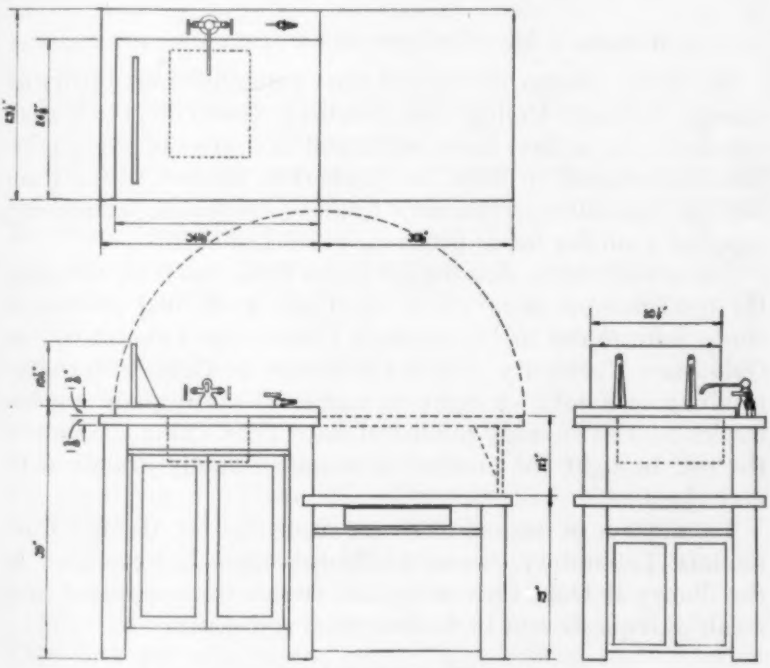
As a service to physics teachers, SCHOOL SCIENCE AND MATHEMATICS has joined with *The American Physics Teacher* in sponsoring the preparation of a list of books recommended as most suitable for the physics library of a secondary school. A list of this kind, if it were carefully compiled, classified, and fully annotated, bears promise of being used widely and should serve materially to increase interest in improving the quality and usefulness of school science libraries. Copies of the list will be made available at cost to all teachers of physics.

To provide a basis for making the final selection, a preliminary list has been prepared in mimeographed form by a committee representing the two journals. Every physics teacher who is willing to give time and assistance to this project is urged to procure a copy of the preliminary list from the Editor, *The American Physics Teacher*, Pupin Physics Laboratories, Columbia University, New York, N. Y. If the final list is to be most useful and dependable, it must represent the collective opinion of a large number of experienced teachers.

A COMBINATION DESK AND DEMONSTRATION TABLE

By William H. Platzer
Kearny High School, Kearny, New Jersey

The room in which this table is located had to be used for both language and science and was too small for both a teacher's desk and demonstration table. This table is a combination of both. As can be seen by the diagram the upper portion can be folded back to leave a desk for the teacher.



A combination desk and demonstration table.

The table is provided with running water, gas and an electric outlet to which can be attached low or high voltage D. C. current and also high voltage A. C. current.

The table was built by our school carpenter. The top has the usual acid proof stain. There are a closet for apparatus and a drawer in the teacher's desk.

OBJECTIVES OF NINTH-GRADE MATHEMATICS IN RECENT COURSES OF STUDY*

By Kathryn McCamey
Butler, Pennsylvania

Fifty-three city and state courses of study for ninth-grade mathematics published since 1929 were analyzed to determine:

1. The type of mathematics provided—whether conventional or reorganized.
2. How the objectives of traditional and reorganized mathematics differ.
3. The character of the reorganized courses of study.
4. Certain other characteristics.

Making a Master List of Courses of Study

Dr. Henry Harap, director of the Curriculum Laboratory at George Peabody College for Teachers, Nashville,Tennessee, supplied a list of sixty-three mathematics courses of study published subsequent to 1929. Dr. Herbert B. Bruner, of the Curriculum Laboratory, Teachers College, Columbia University, supplied a similar list of fifty-four courses of study.

There were thirty-nine duplicates on these two lists, reducing the total number from 117 to 78. Eight additional courses of study were found in Dr. Harap's Curriculum Laboratory, at Ohio State University, and in the library at Duke University, resulting in a total of eight-six names of ninth-grade mathematics courses of study published since 1929. Other changes in the list[1] brought the number of courses actually examined to fifty-three.

Twenty-five of the manuals were studied at Dr. Harap's Curriculum Laboratory. Seven additional manuals were used in the library at Duke University, and twelve were procured as a result of requests sent to various cities and states.

The Check List

To provide for gathering data systematically a check list was made. Various items were suggested by check lists used in previous surveys, by articles on curriculum construction, and by

* Résumé of a Master of Education thesis at Duke University, directed by Douglas E. Scates.

[1] Forty-two of these courses were not obtained for the following reason: 19 were duplications of other courses included in the list, 5 did not exist, 7 were not available, and 11 cities or states did not reply to repeated requests for copies. Of the 44 course-of-study manuals which were received, 9 of them contained 2 courses each for ninth-grade mathematics, making 53 courses of study actually examined.

texts on this subject. The major part of this check list was concerned with objectives. Other items, not here summarized, were included because of their importance in a discussion of objectives.

Definition of Concepts

General objectives, as referred to in this study, are related to the larger outcomes, many of which grow only indirectly out of the subject matter; specific objectives are those which embody the immediate outcomes of a particular body of subject matter.

The term "conventional mathematics" means the course in traditional algebra usually offered in the ninth grade. On the other hand "reorganized mathematics" may refer to any of several types of course, which may be grouped under the following three categories:

1. A fusion course containing elements of arithmetic, algebra, geometry, and trigonometry.
2. Practical mathematics—the purpose of which is to present to the pupil the mathematics that will function in the everyday life of the ordinary citizen.
3. Mathematics taught as a part of the "core curriculum" or "integrated course of study." This idea has been used rather widely in the grade schools for some time, but it has only recently spread to the secondary schools.

Findings: Frequency of Objectives

Of the fifty-three courses written since 1929 and included in the present study, 35, or 66%, offer conventional mathematics; 18, or 34%, offer reorganized mathematics. Included in these figures are nine manuals which offer courses of study in both conventional and reorganized mathematics.

Four courses of study do not list objectives of any kind. Less than fifty per cent of the courses give general objectives for ninth grade mathematics. Of the reorganized courses about 56% do, while of the conventional courses 43% do.

About fifty per cent of all the courses state specific objectives, either for the course as a whole or for units. The specific objectives that are given are usually statements of content. In practically all the courses which list objectives for units, suggestions for realizing these objectives are stated.

Lists of general objectives were compiled for both types of

mathematics. There were seventy-two in the list for the conventional and forty-six for the reorganized courses.

The source and manner of selecting objectives is stated in very few courses of study. The basis for the selection of objectives is not stated in any of the courses.

There is no evidence in the courses of study of any research to establish the validity of the objectives which are stated.

Classification of Objectives

Objectives may be classed as practical, disciplinary, and cultural.[2] General objectives of a practical nature for both types of course outnumber those of either a disciplinary or cultural nature, but they receive more stress in the reorganized than in the conventional courses of study. General objectives for both types of course refer to the practical applications of mathematics, although emphasis upon this point is greater in the reorganized than in the conventional courses of study.

General objectives for conventional mathematics show attempts to make algebra practical through:

1. teaching the applications of algebra in life-like situations;
2. developing an appreciation of the contribution of mathematics to civilization;
3. developing an appreciation of the part mathematics plays in science and industry.

Objectives considered to be disciplinary constitute thirty-three per cent of the general objectives listed in the conventional courses, while they account for only thirteen per cent in the reorganized courses of study.

The general objectives for both types of course show the result of the stress that has been placed upon functional or quantitative relations. However, the conventional courses give this type of objective more than twice as great a place as do the reorganized courses.

In the complete report of the study, the objectives of both types of courses were also classified according to Lide's classification.[3]

Conclusions

Of fifty-three courses of study for ninth-grade mathematics published since 1929, two-thirds of them are conventional, and

[2] The National Committee on Mathematical Requirements, *The Reorganization of Mathematics in Secondary Education*. Oberlin, Ohio: The Mathematical Association of America, Inc., 1923, pp. 6–12.

[3] Edwin S. Lide. *Instruction in Mathematics*, United States Office of Education, Bulletin, 1932, No. 17, Monograph No. 23, p. 19. National Survey of Secondary Education. Washington, D.C.: Government Printing Office, 1933.

one-third are reorganized mathematics. In nine cases both types of courses were provided for in the manual.

Half of the courses give general objectives for ninth-grade mathematics, but none tell how these objectives were arrived at.

Ninth-grade mathematics is still predominantly algebra. Even in the reorganized courses, more units in algebra are taught than in arithmetic, geometry, trigonometry, and practical mathematics combined.

THE NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

The National Council of Teachers of Mathematics will hold its fifth December meeting with the American Association for the Advancement of Science, December 29 and 30 at Williamsburg, Virginia. The following is a skeleton outline of the three programs with the names of the speakers. The general theme is "Mathematics That Functions."

1. Joint Dinner with M. A. A. and A. M. S., December 29, 6:30 P.M.
2. Arithmetic Section, December 30, 9:30 A.M.: R. L. Morton, T. G. Foran, H. E. Benz, B. R. Buckingham.
3. Secondary Mathematics Section, December 30, 9:30 A.M.: H. C. Christofferson, Herbert ReBarker, M. L. Hartung, K. P. Williams.
4. Teacher Training Section, December 30, 2:00 P.M.: F. L. Wren A. J. Kempner, A. A. Bennett, R. L. Morton.

Reservations at a nominal price in the dormitories at William and Mary College in beautiful and historic Williamsburg. For complete details see *The Mathematics Teacher* for November or December.

MAP OF SAUK RIVER, WASHINGTON

A map of the Sauk River from a point about 4 miles above its junction with the Skagit River to Clear Creek, a distance of 20 miles, has just been released by the Geological Survey, United States Department of the Interior. The map is published in 4 sheets, 2 plan, 1 profile, and 1 showing a large-scale survey of a dam site. The plan sheets, prepared on a scale of 2 inches to the mile, with contour intervals of 20 feet on land and 5 feet on the river surface, show the course of the stream, the contour of the valley floor and immediately adjacent slopes, the location of houses, roads, and railroads, and the town of Darrington.

The survey was made especially to determine the potential capacity of a reservoir which would store water for power development and help control floods in the lower Skagit River Valley. The map may be consulted at the field office of the Geological Survey in the Federal Building, Tacoma, or may be purchased from the main office of the Geological Survey in Washington, D. C., for 10 cents a sheet, or 40 cents for the set.

THE EXHIBIT AS A SUPPLEMENTARY METHOD—III. FORMS OF SILICA

By Harold J. Abrahams
Simon Gratz High School, Philadelphia, Pennsylvania

Previous articles in School Science and Mathematics[1,2] have discussed the presentation, by means of exhibits, of subject matter that can find no place in the science curricula, due to the limit imposed by time. These articles suggested evoking student interest by displaying carefully selected specimens of common substances chosen for their beauty of form and color, unusual properties, and wide variation of polymorphous forms. The further suggestion was made that the effectiveness of this method is much heightened by varying the exhibit frequently, both for the purposes of maintaining interest and for enlarging the number of subjects treated. In pursuing this policy, a recent exhibit was prepared upon the subject of the forms of silica and set up in the following manner:

Specimens of oxygen and silicon were placed at the rear of each of two museum cases. Ribbons led from each set of bottles to a large clear crystal of quartz. In Case I, ribbons further led off to cards bearing the captions SANDS, QUARTZ and GEMS, and in Case II, FLINTS, MANUFACTURED PRODUCTS and PLANTS.

The SANDS division was separated into two sections captioned INDUSTRIAL INTEREST and GEOGRAPHICAL INTEREST. Under the former heading were exhibited sands of varying degrees of fineness for water-filtration, sand blasting and iron moulding and very pure sand used for chemical purposes. An opportunity for closer inspection was provided by focusing a magnifier on one of the specimens. The items of GEOGRAPHICAL INTEREST were exhibited mainly to point out the wide variation in appearance of the sands of various countries and to emphasize the abundance of this material in Nature. The QUARTZ division contained specimens, which were selected for their abundance and ease of recognition, or, as in the case of the "Twin Crystals" and "Quartzoid," because of their unusual character. The GEM division was added because the specimens were attractive as well as instructive. The significance of the Chinese proverb that "One seeing is worth a

[1] "The Exhibit as a Supplementary Method—I. Crystallography," December, 1936.
[2] "The Exhibit as a Supplementary Method—II. Forms of Calcium Carbonate," December, 1937.

thousand readings" was amply borne out by the specimens of agate and onyx. The distinction between these two minerals is generally carried in most minds for but a short time unless they are actually viewed side by side. The "Herkimer Diamonds," the pure crystalline silica which so closely simulates the genuine diamond, endowed the exhibit with a fabulous value, to those who knew no better. The most unusual thing in the case however, was a remarkable specimen of wood opal,[3] in which it was possible to observe at the same time the external woody portion of the twig and its interior of clear, iridescent opal.

Case II contained a small collection of Indian arrowheads[4] and other implements and ornaments, made of flint. They attracted much attention. Under "MANUFACTURED PRODUCTS" it would have been possible to exhibit many specimens but lack of space curtailed the number.

Only commonly known specimens were selected for the "PLANT" division. Several other illustrations such as equisetum, etc., will suggest themselves, if space be available in the

[3] Courtesy of Mr. Morrell G. Baldwin, Philadelphia, Pennsylvania.
[4] Courtesy of University Museum, University of Pennsylvania, Philadelphia, Pennsylvania.

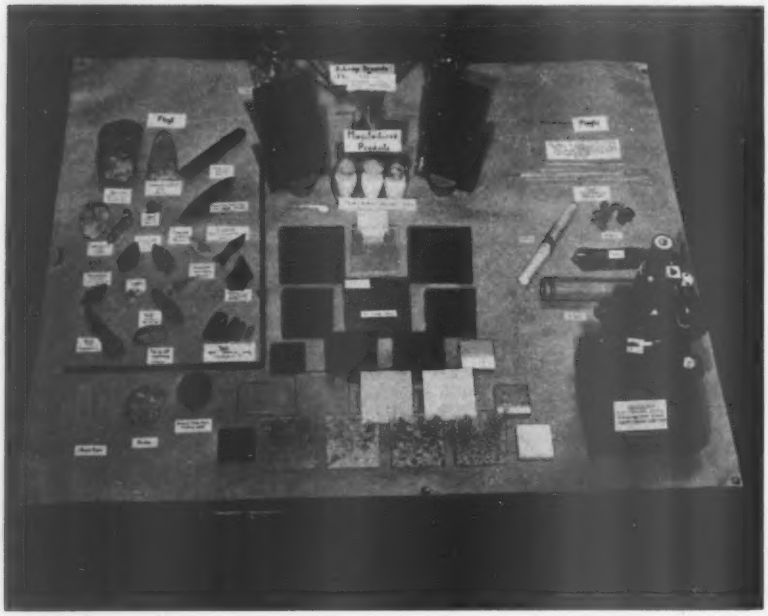
museum case. An interesting feature in this division was a field of diatoms under a microscope.

The accompanying photographs[5] offer a graphic representation of the arrangement of specimens. As the natural coloring of these specimens is not here reproduced, their aesthetic appeal will not be evident to the reader.

Above the exhibit was placed the following typewritten plaque:

SILICA

Everyone is familiar with the very common material, sand. Few persons, however, realize that silica, of which sand is largely composed, is found in a large number of different forms. In this exhibit you will see dozens of kinds of silica, varying in form and purity. Upon these factors (form and purity) depend the use and value of these different varieties.



When silica sand is fairly pure it is made into glass by melting with lime. Other pure forms of silica give us the highly esteemed "crystal," for art-objects and jewelry, and quartz for chemical-ware. Chemical apparatus, made of fused quartz, may be heated to redness and plunged into ice water, without danger of cracking.

Silica is found in Nature in so coarse a form as to be useful for making sand-paper. It is also found so fine-grained as to be used for silver-polish. Another extremely fine-grained sand, sold as "foot-ease," is used in a way

[5] Courtesy of Mr. Mark H. Hagmann, Simon Gratz High School, Philadelphia, Pennsylvania.

similar to talcum powder. Thus we see what a wide range there is in the size of grains of silica or sand.

The degree of purity may also fluctuate. Certain impurities make some specimens very valuable as gems, while other impurities render some worthless, even for building purposes. In this collection are shown numerous gem materials, in unpolished form. Though these differ in appearance, they are all largely silica, the only difference being in the kind of impurity. On the other hand, the presence of iron as impurity in sand is sometimes unfavorable, because mortar made from such sand will interfere with radio broadcasting. Thus, on the one hand we pay a high price for the presence of the trifling impurity in cat's-eye, amethyst, carnelian, onyx, etc., while on the other hand, we may altogether reject sand for building purposes, on account of its impurities.

Not only is silica the basis of giant mountains, huge rocks and spreading shores, but it also plays an important role in many forms of life beginning with the simple diatom and ending with man. It is even present in the human eye. Perhaps its greatest benefit to man is the type of civilization it has made possible for him. Think of the age of flint implements! What turn might human civilization have taken, had it not been for flint arrowheads, etc.? Likewise glass, a manufactured product, has brought man countless blessings. For this we may also thank silica.

Yet invaluable as is sand, the commonest form of silica, it remains little understood, perhaps little appreciated and certainly undefined. It is, for instance, claimed that a railroad carrying sand to three manufacturing plants, located next door to each other, will charge three different freight rates. This is because, lacking a clear definition of sand, the freight rates to the different manufacturers will depend upon the uses to which it will be put by them, even though each firm receives the same kind of material.

Because it is so natural to take such a common substance as silica for granted, we may well recall the lines of Young in "Love of Fame":—

> "Think naught a trifle, though it small appear;
> Small sands the mountain, moments make the year,
> And trifles life."

List of Materials in the Exhibit

Case I

Specimens of Silicon and Oxygen
Specimen of pure Silica

Sand

A. Industrial Interest
   Twenty varieties varying in degree of fineness and use.
B. Geographical Interest
   Twelve varieties varying in geographical origin and therefore in appearance and composition.

Quartz and Gems

2 Quartzoid	Fowler, N. Y.
1 Twin crystal	Japan
1 Smoky quartz	Bedford, N. Y.
1 Amethyst	North Carolina
2 False topaz (citrine)	Spain
7 Herkimer diamonds	
1 Rose quartz	Bedford, N. Y.
1 Tiger-eye	Griqualand, Africa
1 Chalcedony	Tampa, Fla.

1 Agate	Brazil
2 Moss agates (polished)	China
1 Carnelian (polished)	India
1 Onyx	Brazil
1 Chrysoprase	Transylvania
1 Bloodstone (heliotrope)	India
2 Jasper	Ariz., Cal.
1 Flint	Dover, England
1 Silicified wood	Antigua
1 Opal	Nev.
1 Hyalite (Muller's glass)	Bohemia
1 Quartz pseudomorph	Cumberland, Eng.
7 Quartz crystals (odd)	

Case II

Specimens of Silicon and Oxygen
Specimen of pure Silica

Flints

4 Beads (1 agate, 2 carnelian, 1 quartz crystal)	Colombia
Chalcedony bar-amulet	Mexico
Chalcedony arrowhead	Mexico
Quartz arrowhead	Mexico
Flint spearhead or knife	Mexico
Obsidian arrowhead	Mexico
Obsidian core from which knives were struck	Mexico
Obsidian flake knife	Mexico
Obsidian labret	Mexico
Flint knife, oval	Flint Ridge, Ohio
Flint flake (knife?)	Flint Ridge, Ohio
2 Flint arrowheads	Flint Ridge, Ohio
Flint scraper	Flint Ridge, Ohio
Flint drill	Pennsylvania
Quartzite knife	New Jersey
Yellow jasper axe-head	Pennsylvania
Red jasper arrowhead	Pennsylvania
Pink quartz barbed point	Eastern U. S.

Manufactured Products

25 specimens of glass
Raw materials for making glass (sand, soda, and limestone)
Specimens of genuine ruby glass
Mortar
Sandpaper

Plants

Straw
Piece of corn stalk
Piece of bamboo
Mistletoe
Pandanus leaf
Infusorial earth under microscope with explanatory note on diatoms

The collecting of materials for exhibition purposes is not as difficult a matter as it may at first appear to be. Most business firms are quite generous in furnishing splendid material upon

request. Some museums are very happy to place at the disposal of teachers any duplicates which they may have of permanently exhibited specimens. Private collectors are also often willing to lend certain specimens to teachers for short-time exhibition. Experience has shown that teachers need feel no reluctance in the matter of asking for loan-exhibition material from various sources, as the response from these is in most cases very gratifying and encouraging.

COMMENTS ON THE HEAT EXCHANGE PROBLEM

Cornaigmore H. G. School
Cornaig, Scarinish, Isle of Tiree,
Scotland. 10/10/38

The Editor
"School Science & Mathematics"
7633 Calumet Av.
Chicago, Illinois, U. S. A.

Dear Sir,

I write with regard to the article "A new technique for solving heat-exchange problems" on p. 801 of your current issue.

You may be interested to hear that the essentials of this "new" technique have been used by me for ten years and, as I learned it in a Scottish Secondary School twenty years ago and have seen it employed in at least two others, I imagine it is quite commonly used here.

Further, there are one or two points on which I consider our practice to be superior:

1. "$\Delta t = 10°C.$" Δt is not a definite temperature but a *range* of temperature and should therefore never be indicated by "°C." but by "C. deg." or "Cent. deg."

2. "Heat gained = Heat lost." The use of "lost" is very confusing to the child here. Energy cannot be "lost," and when the principle of Conservation of Energy is reached the child who has been taught to say and write "heat lost" will be lost himself.

Even if this be not granted, then at least the term "lost" should be kept for heat dissipated by cooling, radiation, etc., during the experiment, which always results in practice in *fewer* calories being taken in by the "cold" body than are given out by the "hot" one (so-called).

Further, the bald statement "Heat gained = Heat lost" is paradoxical and perplexing unless modified so as to make clear that "gained" and "lost" do not apply to the same body but to two different bodies.

Hence, I always use "Heat taken in by cold [body] = Heat given out by hot [body]," in most cases substituting for [body] the actual name of the body concerned, which may of course be complex, as in the case of "water and calorimeter can."

Yours faithfully,

John R. Morrison, M.A., B.Sc.,
Headmaster and Principal
Teacher of Science.

A SCIENCE PROGRAM FOR THE SCHOOL CLUB OR ASSEMBLY

By C. K. Chrestensen
Clairton Public Schools, Clairton, Pennsylvania

In the struggle to gain a living the average individual has little time to observe the interesting phenomena about him. All too often some important scientific happening takes place, such as the falling of a meteor, or a new invention, with only passing mention of the event. Short accounts of the occurrence may be scanned over in the newspaper, but beyond this it is catalogued as another scientific mystery.

Science has been termed "exact nonsense." A great many people consider it a mass of useless complicated knowledge. Some have gone so far as to charge that the scientist speaks an unintelligible language. As a result of these misconceptions, the society of today has great need for a better understanding of scientific principles. A conscientious effort on the part of science teachers to clarify these misconstrued opinions for the student and the school patron will do much to improve conditions. The parent is interested in the welfare of the child and when that interest is centered in the community educational institution the result will be a stronger, better, public school. On this basis the science assembly program may be made to play an important part.

Almost any science has a rich fund of material which may be used for the science club or assembly program. The subjects for the demonstration should be taken from the classroom work, although students sometimes like to develop other ideas. Pupils taking part in the program should practice their parts several times and the teacher should be sure they have an understanding of what is expected of them. Experiments of a more dangerous nature should be performed by the instructor.

The program explained in this article consists of demonstrating some odd methods of lighting. The writer and his students have presented this program with good results. In working out the details the experimenter should divide the demonstration into four parts. One group of students may be called upon to illustrate light production by "incandescence." Another may show how light is produced by chemical reaction "chemiluminescence." The third group may exhibit light production by "fluorescence," while in the last part of the program the production

of light by "phosphorescence" can be shown. The explanations of the various parts will contain as much material as the limited space will permit.

Light Production by Incandescence

A demonstration of lighting by incandescence may be shown in a number of ways. A piece of copper wire should be stretched between two supports and connected to a 110 volt circuit. Of course the science teacher knows the wire will be melted. The experiment serves as a method of illustrating the oxidation of a filament. This may be demonstrated in another way by making a small hole in an ordinary incandescent light bulb. When this bulb is placed in a socket, the current will immediately oxidize the filament, blowing the oxide out through the hole. The use of an ordinary photographer's flashlight bulb provides another method.

Incandescent lighting may also be demonstrated by use of a small carbon arc. When this is connected to the lighting circuit the vaporization of the carbon produces the well-known carbon arc light. This method may be supplanted by the mercury arc lamp. Frequently, one may find in the community a health lamp of the G5 clear glass type.[1] This serves to show how light is produced by the vaporization of a metal. If such a lamp is not available, the experimenter may wish to substitute the "lighting kit," which may be procured from a light company[2] for a small rental fee. The equipment may be kept for one week, and consists of many types of light bulbs, including a replica of Edison's first electric light.

Light by Chemical Reaction

White phosphorus dissolved in a solvent may be used to demonstrate this method of lighting, but it is a dangerous material for the student to handle. In the last few years a much more suitable material has been found in the organic chemical substance known as "3-aminophthalhydrazine," commonly called luminol. This chemical has taken the place of phosphorus, because it is absolutely harmless in the hands of the student. It also has the advantage of giving more light when the mixture is exhibited in a darkened room.

Preparation of the Light-giving Solution. The materials for this

[1] Westinghouse Lamp Company Office—the nearest large city.
[2] General Electric Company, Nela Park, Cleveland, Ohio.

solution must be carefully mixed to secure the desired results. Two solutions are necessary and these must be mixed together to produce the lighting effects. In the first solution about 0.4 of a gram of 3-aminophthalhydrazine should be dissolved in forty cubic centimeters of a five per cent sodium hydroxide solution. This chemical mixture is then thoroughly stirred into one gallon of water. The preparation of the second solution is achieved by dissolving one and one-half grams of potassium ferric-cyanide in forty cubic centimeters of hydrogen peroxide. This should be mixed into a similar amount of water. The two gallons of liquid will provide sufficient quantity to demonstrate the chemical luminescence in a large auditorium.

Producing the Light. The writer has had good results by carrying out the demonstration as follows: Secure a large glass having a capacity of not less than two gallons. A large battery-jar may be used or one may purchase a small aquarium from the department or novelty store. Pour into the container the one gallon of the ferric-cyanide peroxide mixture. The gallon of luminol-hydroxide mixture should be made ready so that the experimenter can find the container. After the lights are turned off, the experiment may be performed by pouring the luminol solution into the liquid in the aquarium. The light produced as the two solutions are mixed together provides a beautiful spectacle. The amount of the light may be greatly increased by adding one or two grams of powdered potassium ferric-cyanide followed by a few cubic centimeters of the hydrogen-peroxide. The reaction does not produce any noticeable heat. A small piece of ice may be dropped into the liquid without lessening the luminescence and serves to provide more novelty in performing the experiment.

Pouring from Two Pitchers. The luminous liquid can also be demonstrated by pouring from pitchers. The experimenter should procure two two-quart glass water pitchers. These should be filled with the potassium ferric-cyanide peroxide mixture and the luminol hydroxide solution. To perform the experiment, the pitchers should be held high over an empty glass battery-jar, and poured so that the two streams will come together about 10 inches above the container. In the dark auditorium it will appear as if the stream is coming out of the air above the jar.

Luminous Tube. This experiment with luminol must also be performed in a darkened auditorium. It will be necessary to procure two large bottles of two or three gallon capacity. These

should be arranged on supports at least four feet above the top of the table. One bottle should be filled with the luminol and the other with the peroxide ferric-cyanide solution. A siphon tube should be attached to each bottle and these should be connected to a glass T. From the lower end of the T a five-foot length of one-fourth inch glass tubing should be attached with rubber. This may be extended down to a large glass battery-jar on the floor or at the opposite end of the table. Prior to performing the experiment, the siphon should be started and then stopped by two metal clamps. When ready to perform the experiment, the clamps should be removed. The two solutions will siphon over and be mixed in the T, thus producing a luminous liquid in the five-foot tube. This light-giving liquid will be seen to run down the glass tube into the battery jar at the far end of the table.

Fluorescent Lighting

Light production by fluorescence is the most interesting of the four methods described in this article. It is necessary to procure a good source of ultra-violet light, since objects are not fluorescent without the short wave radiation. The cold illumination may be obtained by a carbon arc or one may purchase a black bulb[3] from a light company. In case the former source is used a black glass filter will be needed to remove the visible ultra-violet light.[4] In the latter light source a special reactor must be procured to reduce the voltage. It should be understood that all fluorescent experimentation must be performed in a totally dark room or auditorium.

The making of the fluorescent liquids and paints is a second qualification that must be met in order to carry out this part of the program. These light-giving substances may be purchased[5] from various companies, but the preparation provides an interesting project for the science class or club. Fluorescent liquids are easily made by bringing into solution a few dyes or other chemicals. In most cases these materials should be very dilute. One-twentieth of a gram dissolved in a quart of water is usually sufficient. The ultra-violet light-sensitive chemicals may be obtained from any good chemical firm.

The following solutions give excellent fluorescence when viewed in filtered ultra-violet light.

[3] Westinghouse Lamp Company.
[4] Corning Glass Company, Corning, New York.
[5] Continental Lithograph Corporation, Cleveland, Ohio.

Dye or Chemical	Solvent	Color Ordinary Light	Color Ultra-Violet Light
Rhodamine B.	Water	Red-orange	Strong Red
Eosine	Water	Pink	Orange
Fluorescein	Water	Pale Yellow	Strong Yellow
Primuline	Water	Colorless	Light Green
Anthracene	No solvent; one ounce mixed into one quart of benzol with 20 grams of paraffin and 20 grams of vaseline.	Light Brown	Medium Green
Esculin	Water	Colorless	Strong Blue

Fluorescent paints may be made by dissolving small amounts of the following chemicals in alcohol and mixing with lacquer or cellulose acetate acetone solution.

Dye or Chemical	Solvent	Color Ordinary Light	Color Ultra-Violet Light
Rhodamine B	Alcohol	Orange	Red
Rhodamine 6G	Alcohol	Yellow	Orange
Eosine (Strong)	Alcohol	Orange	Deep Orange
Powdered Anthracene(Solid)	Stirred in cellulose acetate solution	Brown	Strong Green
Primuline (Strong)	Alcohol	Brown	Dark Green
Auramine	Alcohol	Yellow-brown	Yellow-green
Powdered Sodium Salicylate	Stirred in solution of cellulose acetate	White	Blue
Powdered Sodium Salicylate & few drops lubricating oil	Stirred in cellulose acetate	Yellow	Light Blue

While there are many substances that exhibit some fluorescent characteristics, the chemicals given in the preceding list have strong light-giving properties in ultra-violet light. The writer has found that white cloth treated with these substances will be visible at 500 feet in a dark auditorium.

Uses of the Liquids. Very beautiful lighting effects may be produced with these chemical solutions.[6] Almost any color of the rainbow may be obtained by putting the liquids in large test tubes and bringing them within range of the short wave light. Another color spectacle may be produced by dipping

[6] Chrestensen, C. K., "Science in the High School Assembly," *School Activities*, December, January, February, 1937–38.

squares of white cloth in the fluorescent liquid. Unique dance costumes may be made by treating light colored garments in a similar manner. The cloth should be allowed to dry before it is viewed in the cold light.

Use of the Paints. The luminous paints have even greater light producing possibilities. The lacquer paints may be brushed on cloth or paper. Thus, the experimenter may prepare for exhibition fluorescent flowers, posters and invisible signs. In fact, this method of fluorescent lighting provides sufficient material for several assembly programs.

FIG. 1. Students wearing partial fluorescent costumes seated in front of a fluorescent treated screen. This photograph was taken in ordinary light.

PHOSPHORESCENCE

Almost everyone is familiar with the term "phosphorescence." This is especially true at present, because nearly every home contains a watch, clock or some other article that emits light in the dark. There are, however, a number of points concerning these phenomena that should be clarified. First, it should be understood that phosphorescence is not as common as fluorescence. The second point to be explained is that a clear distinction be made between fluorescence and phosphorescence. The

two terms are easily distinguishable if we remember that a fluorescent substance is visible only when short light waves such as ultra-violet strike the object. A phosphorescent substance is also excited by light, but when the light source is removed the object continues to give light for some time. Lastly, it should be understood, that if a luminous material is placed in a totally dark room, it would in time cease to be phosphorescent while it remained unexposed to light. Since, under ordinary conditions, a luminous article does receive some light, it is activated to the extent that it continues to be phosphorescent day after day.

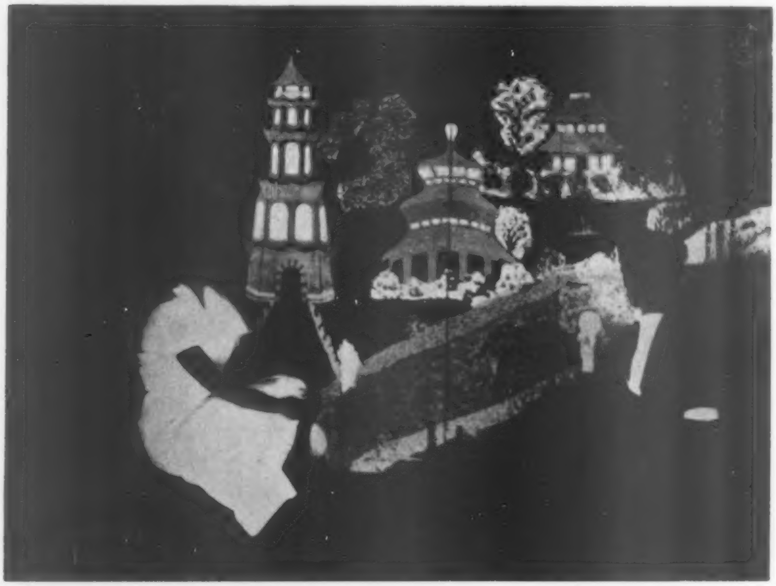


FIG. 2. The same picture taken in ultra-violet light. The beautiful colors produced are almost unbelievable.

Phosphorescent Paints. Phosphorescent materials may be prepared by heating various chemical combinations to a high temperature or by activating these combinations with radio active substances. The experimenter will encounter some difficulty in preparing these prolonged luminescent materials. The average laboratory is not equipped to give the intense heat required, and radio active substances are either not available, or they are too expensive to be used for this purpose. The demonstrator will also find other difficulties if he attempts to prepare the luminous substances. Complex chemical compounds are neces-

sary in many cases. These are not only difficult to obtain in small quantities, but the cost is excessive, thus making it prohibitive. Prepared paints also are costly so that the experimenter is really left with the one alternative of purchasing the phosphorescent material and preparing his own paint. However, if the demonstrator wishes to prepare some phosphorescent materials, a reference will be given for convenience.[7] In purchasing phosphorescent chemicals, luminous calcium sulphide is the most economical. Zinc sulphide gives a better phosphorescence, but it is decidedly more expensive. The calcium compound produces a bluish purple light, while the irradiated zinc sulphide produces a strong, yellowish-green color.

Preparation of Paints. In making the phosphorescent paints the following procedure has been carried out with good results. Cellulose acetate should be dissolved in commercial acetone. Sufficient acetone solvent should be added to dilute the solution down to a thin sirupy liquid. The paint may then be prepared by mixing a small amount of the phosphorescent calcium or zinc sulphide into the cellulose acetate solution. In using the calcium, care should be taken to add the sulphide, a little at a time, with thorough stirring after each addition. This is necessary because the solution thickens quickly if too much of the sulphide is added. A very small amount should be mixed at one time and this should be applied quickly to avoid hardening. If these directions are not followed in using the calcium, the mixture may become so thick that it cannot be spread. A good grade of lacquer may be used instead of the cellulose acetate solution and in some cases serves well, since the paint adheres better when used on hard surfaces.

Phosphorescent Clock. The clock face may be made from a large piece of cardboard. Numerals can usually be made by mechanical drawing students. The clock hands may be made of wood. In making the numerals and hands phosphorescent, best results may be obtained with the zinc sulphide, although at considerably greater cost than with the calcium compound. When the face and hands of this skeleton clock are exposed for a few minutes to daylight, ultra-violet, or a strong incandescent lamp, the light emitted makes it possible to see this clock the entire length of a darkened auditorium.

Magic Wand. An ordinary one-half inch diameter wooden rod may be coated with the phosphorescent paint. Since this rod

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[7] *Henley's Book of Formulas.* Norman W. Henley Publishing Co. 1933, pp. 494–495.

is luminous in the dark, it makes a weird addition to the paraphernalia of a dancer wearing a luminous treated costume.

Dance Costume. Parts of clothing may be covered with the phosphorescent paint. In order to secure the best results, the zinc sulphide should be used. A rather comical effect may be obtained by treating a glove, a mask, a part of a trouser leg, and a part of a sleeve. Various students may then wear these garments, and if they are all shown on the stage at one time, the ingenious teacher can work out some weird effects. It must be understood that a completely darkened auditorium is necessary and the phosphorescent costume must be exposed for several minutes to daylight, ultra-violet, or a strong incandescent light before showing on the stage.

Phosphorescent Skeleton. A life-sized cardboard skeleton can be purchased for a few cents at Hallowe'en time. In order to make the skeleton phosphorescent, it should be treated with the zinc sulphide luminous paint. Some experimenters may consider this too expensive due to the excessive cost of zinc sulphide. It should be stated, therefore, that fair results may be obtained with the calcium sulphide paint. The light-giving material should be applied to the cardboard with a small brush. These weird figures create great amusement when exhibited before an audience.

Shadow Cloth. The shadow cloth presents an interesting method of demonstrating phosphorescence. One way of doing this is to paint a one yard square of white muslin with a thick coat of the luminous cellulose calcium sulphide paint. When this cloth or any part of it is exposed to ultra-violet or incandescent light it becomes strongly phosphorescent. The phosphorescent qualities may be demonstrated as follows: Keep the treated cloth in a dark place for several days before the exhibition. In order to leave the shadow on the cloth, hang it on some support in such a way that the strong light from a slide lantern may be thrown on the screen. The demonstrator should stand in front of the unexposed cloth and have someone turn on the slide lantern so that his shadow is thrown on the screen. After two minutes' time the slide lantern may be turned off and the experimenter may walk away, leaving his shadow visible to the audience in the darkened assembly hall. The following method may be used in case the slide lantern is not obtainable. The outstretched hands of the student should be placed on the unexposed cloth. This should then be held in a strong incandescent

or ultra-violet light source. After several minutes the light can be turned off and the luminous cloth will show the darkened shadows of the hands.

Phosphorescent Celluloid Sheet. A celluloid sheet treated with zinc sulphide luminous paint may be used as an alternative method of showing a shadow. The sheet should not be exposed to light for several days. When it is brought within the rays of a strong light for a few moments, an outstanding shadow will be left on the celluloid material.

The value of this type of science assembly should be obvious to the science teacher. The first part of the program not only shows the necessity of having an absence of air or the presence of an inert gas in the light bulb, but also shows how light is produced by the vaporizing of a metal. The second section of the demonstration illustrates a striking method of light production by chemical means. Due to increasing interest in fluorescent lighting, the third part of the program serves to give an advanced insight into future methods of lighting, and also brings out the fact that chemical materials will alter the character of short wave light. The final part brings to the attention of the student the fact that some chemicals have light gathering characteristics, and that objects are phosphorescent because of this property.

From the educational point of view, it may be assumed that students will learn a useful lesson in helping to develop the program. Added to this is the training afforded in presenting the performance before an audience. Looking at the demonstration through the eyes of the assembly student one sees a visual science lesson presented in a manner not easily forgotten. If one considers the entertainment from the angle of the adult, it is found that these exhibitions aid in educating the community to the fact that science is something more than formula. In conclusion it may be said that the high school assembly presents many opportunities for training the student; opportunities that with a minimum of effort can be transformed into useful education.

ARCTIC SHIPPING

The 1938 Arctic navigation season is now practically over. During the past months, Soviet ice-breakers released 24 cargo steamers that had been frozen in, along the Siberian and European Arctic coasts, while airplanes brought supplies and removed part of the personnel. The various fleets brought out a total of more than 40,000 tons of timber, minerals and other products. Plans for the 1939 season are now under way.

THE PRIMARY PURPOSE OF TRAINING IN MATHEMATICS—NOT A KIT OF TOOLS BUT A WAY OF THINKING

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Any method of teaching mathematics as a way of thinking must be closely interwoven with function as a basic, unifying concept, and with transfer as one of the fundamental ideas. A plan of presentation that at all points emphasizes relationships and dependence of one variable upon another will result in the pupil's development of a very desirable way of thinking. Also, a method of teaching which has for one of its foundation stones a belief in and an understanding of transfer possibilities will produce a high degree of conscious power in clear, systematic, logical thinking. The leadership will be not for the attainment of this skill or that as an end, but toward the recognizing and appreciating of basic, fundamental ideas and ideals, principles and processes, habits and attitudes.

While fully realizing that a "way of thinking" cannot be made the primary purpose of courses in mathematics without using functionality and transfer as two of the most important elements in method of procedure, we shall, however, at this time hold our attention closely to a comparison of the ideas: mathematics, a tool subject, and mathematics, a way of thinking.

There may be listed in brief form a number of reasons why it is not good that a teacher should think of mathematics simply as a tool subject.

1. There are a few tools to be acquired in this subject, which are almost sure to be of practical value to everyone. But if acquired in a mechanical, follow-the-rule fashion, their acquisition being held as if first in importance, they are never well sharpened, and if not in constant use, very soon rust.

2. Of that much larger group of tools that may be acquired in a mathematics class, only two or three pupils at most will ever make practical use of exactly the same kit of tools. It is foolish to drill all for the special use of a set valuable only to farmers, or to insurance agents, or to mathematics teachers, or to chemists, or to engineers. And, too, it is impossible to extend the day so as to include all.

3. Modern inventions are rapidly turning overboard many tools of even the very recent past.

4. Teaching for the adding of tools one after another, gives disconnected ideas, each to be used only in a narrow particular situation, in no sense reaching out to help in different fields.

5. To the majority of young people there is a fascination in juggling figures so long as the directions are simple and plain, and the answers pop out which the teacher says are correct; this procedure, however, does not lead to lasting pleasure in mathematics.

6. When the tools are acquired separately, each as an end in itself, they often become confused in the pupil's mind, so that he attempts in many cases to use the wrong rule. Large numbers of young people are totally bewildered because of having been exposed to the use of so many tools, and not being able to remember just how and when to use each one.

7. The harm of this viewpoint in teaching is evidenced in the not uncommon remark of more or less cultured, successful men and women who say, "I took all those courses, but it was wasted time. I don't remember a thing about them except the suffering, the dread of failure, the unhappy times at home in regard to help given me. I'd have lost nothing, and in fact be better off today, if all the mathematics beyond a little bit of simplest arithmetic had been omitted."

8. The different parts of the business, professional, and educational world. complain that an exceedingly small number of young people learn to perform the simplest processes of mathematics well.

9. Accumulating tools one by one, produces no lasting skill even in the use of those very tools; and such a method furnishes no incentive to go on in the study of mathematics, or to appreciate what it has done for the comfort and convenience and progress of all mankind; furthermore, no growth, development, improvement has come about in the consciousness of the pupil, —no better way of attacking the problems of life.

Now let us look at methods to see which are poorly adapted and which are best adapted for developing that desirable "way of thinking."

The drill method, either old or new, as generally administered, is mere routine manipulation destructive to real growth in thinking. Under it, pupils are worked up to make higher and higher scores on standardized tests; then a short while afterward

show almost no retention, no power even of using the simplest tools in the same situations as those in which they were first presented. To apply them in different situations, however similar, appears utterly hopeless.

Plenty of drill there must be, but thinking, meaningful, motivated drill that does of course bear fruit in good test scores, and, what is of far more importance—results in a good degree of retention of the skills, and in fixing in memory the fundamental principles. It is to be emphasized that a worth-while drill is on points already thoroughly understood.

It is well known that every day in many schools, quantities of paper are covered with drill exercises that have no more value than a long list of puzzles and games. There is merely a "follow the form," or "flip the symbols," or "fit things in as per sample," with the use of observation and memory only—with no evidence of even a glimmer of mathematical thinking. Growth in observation and memory are, of course, tremendously valuable in all fields, but it is high time we, ourselves, awaken and do our best to help arouse others, from the delusion that the exercise of those two factors alone when preparing daily stints of "busy work" in arithmetic, algebra, or geometry, will or can develop in boys and girls any degree of power in clear, straightforward thinking.

Even if we, as grown-ups, thoroughly understand and greatly enjoy accomplishment, a good advance toward mastery in piano work, in stenography, in calculus, in astronomy, in chemistry, or in French, and then completely drop the subject for a number of years, not using it at all, never talking of it with any friend, not even thinking of it, we find it has almost disappeared from memory.

How much more completely and how much sooner it is lost if never enjoyed nor really understood. Also, when not at all comprehended, the memory work is like learning a list of nonsense syllables with no meaning for us. And furthermore, besides sinking out of consciousness sooner, there was no value in the experience at the time of first exposure. (That is, no value to the pupil. A few teachers are greatly relieved in being able to supply plenty of material such as it is, to keep Johnny and Mary occupied and out of mischief.) On the other hand, the pleasure in acquiring a worth-while process or skill or set of facts when perfectly understood at every step, does something to one, emotionally and intellectually, so that thereafter he

lives in a different world from what would have been his otherwise. This different world is wider and richer in vision and appreciations and possibilities.

The activity program and the project method and integration as recently propagandized, all show the pendulum at the other extreme. These not only point out the weak spots in unthinking drill, but declare that no systematic drill is necessary, no continuity or sequence of points presented, no value in the subject of mathematics as such, except for the few who will become teachers in that field, or who will follow careers that necessitate the thorough knowledge of college mathematics. These assume that "incidental" learning in this subject is sufficient and best.

From those who believe in these methods we hear about the vast amount of time spent in arithmetic, algebra, and geometry, with so small a degree of mastery as a result. Is the degree of mastery in other subjects—reading and composition for example—worthy to receive high praise? What type of mastery will be gained from many hours of many days spent in watching, talking about, or taking a small part in the building of something which is really not needed, or of carrying on the makebelieve of some business? Recently we read of a small boy in a room where the activity program was possibly carried a bit too far. Upon being asked how he liked school, he replied, "Oh, pretty well, only I do wish we could graduate from that silly grocery store." Can much real power in good thinking be expected from long drawn out, wordy discussions of some problem of social or economic reform which expert, mature, experienced men do not understand?

Activity program, project method, Dalton plan, socialized recitation, progressive education, correlation, the last more recently revived, given a different turn, and renamed as "integration," have all arisen because of some teachers seeing plainly the weaknesses in our system. Had we, some time ago, been vigorously at work improving, cutting, reorganizing, and enriching our curriculum, and constantly improving our methods of presentation and drill, securing a larger number of well trained teachers having special fitness and joy in the work, these various plans would have found no great need of radical change upon which to stand when pointing the way to the impractical, dizzy heights to which some of their proponents have soared.

Let us hasten to repeat: There is great need of radical change in our courses and in our methods. These more or less modern movements have made us squirm as they point the finger at weak spots. They have emphasized thoroughly sound principles in regard to interest, freedom, unthinking manipulation, practicality, prevention of inferiority complexes, waste of time, lack of mastery, understanding, development of individuality, cooperative thinking, training for life, and real, normal living in the school room.

Is there not danger that in enthusiasm for correcting these errors, we jump from the frying pan into the fire? Should we not correct the errors, strengthen the weak links, and toss overboard what is obsolete, or for any reason without definite value, but avoid while getting rid of the tares losing the wheat also? There is much fine wheat in mathematics as a separate subject when well taught by experienced people with deep insight into the greater possibilities of helping to develop power and joy in clear thinking. If the job is not done now as well as it ought to be—and, of course, this is frankly admitted—is it reasonable to suppose it will be better done "incidentally" as a service subject, with teachers having no special training and no great interest in or appreciation of the task?

What are some of the outstanding characteristics of the mathematics work in a school system where the primary purpose of that department is believed to be growth in power to think well? A briefly worded list can point the way even when there is time for but little discussion.

1. Teachers with special fitness, interest, and training both in mathematics and in its teaching.

What about the excellent football coach with a period free to sit in the mathematics class room, assigning problems, showing a sample solution, and reading answers from the answer book? What about the splendid music teacher given a class in arithmetic, who asks where the decimal point goes in division? What about another who says that if 240 dollars is 5 per cent of something, you multiply by 5 per cent and then add that onto the 240, and who also marks the answers 4.3125 per cent and 4.3 per cent both wrong, saying that it must be $4\frac{5}{16}$ per cent, that "decimals are never used with per cents"? How much power to think mathematically comes to a class under such leadership?

One more illustration of this type: A social studies teacher,

when asked to take an algebra class, said she could not, because it had always been very hard for her, and she had never understood it herself. The principal replied, "Just ask Miss T. to do sample problems for you in each set, and then have the pupils follow the form; here is an answer book."

Would one send a boy or girl for music lessons to a teacher with correspondingly poor training and fitness? Is it any more sensible to say, "Oh, anyone can teach mathematics," than to say, "Anyone can teach music"?

2. Great increase in concrete experience.
3. Formal arithmetic begun much later in the grades.
4. Academic algebra and demonstrative geometry not offered until the second half of high school years.
5. Simple algebra, intuitive geometry, and numerical trigonometry presented in seventh, eighth, and ninth years.
6. Arithmetic training throughout senior high school, some points reserved for the twelfth year.
7. Fewer topics each term, all thoroughly understood.
8. No point introduced until maturity is sufficient for real comprehension.

The second point, great increase in concrete experience, applies both to early school days, before any formal, abstract arithmetic has begun, and also all along the line through elementary and secondary grades.

We have built up a system greatly lacking in background of concrete experience. No individual teacher of any grade is to blame for this, but here lies one, if not the greatest, cause for our mathematics courses failing to develop power in clear thinking.

Young people maneuver with symbols they do not understand, and so very early stop trying to apply common sense reasoning. An intelligent boy gives as the answer to a problem that a ton of coal costs 5681 dollars or that the interest for one year on 700 dollars is 4200 dollars. Out on the playground, if one of his pals declared that his father had just paid 5681 dollars for a ton of coal, the retort would come instantly, "Aw, you're kidding me." And if told that a man paid 4200 dollars for one year's use of a loan of 700 dollars, the quick response might be, "You're crazy. Nobody'd do that." Each of you can list many instances just as absurd. Why do intelligent boys and girls fail to think intelligently in such cases in the class room?

Before answering that question, let us ask another, for both

can be answered in the same way. Why can normal young people take part in a conversation like this? "Do you multiply these numbers?" Teacher looks astonished or hurt or disgusted. "Oh, then you add 'em?" "But, John, don't you see they can't be added, they are not the same kind of thing." "Well," hopefully, "is it substract?" Then at the teacher's look of utter despair, he says, "Oh, you divide 'em."

What is the cause of both of these deplorable situations? All along the way of arithmetic, instead of understanding every step and so really reasoning, and growing in power to think clearly, observation and memory alone are used; geometry topics are presented before there is experience and maturity and foundation absolutely necessary for understanding of the topic.

In the consciousness of many boys and girls, outside common sense reasoning is wholly separate from school room lessons in arithmetic, algebra, or geometry. There is "do it like the sample," follow directions as in a puzzle, hope there'll be no slip in the routine, and the answer will pop out that the teacher accepts. If the result obtained is exactly half as large as they say is correct, won't multiplying it by two, make it all right?

Small children are wonderful little parrots. Consciousness is not yet crowded with as great a variety of interests as will come later. They can easily commit to memory and relay back to you a great deal that sounds fine, when to them it has no more meaning than if it were composed of sentences in Choctaw.

The present trend toward beginning formal arithmetic much later is plainly based on the desire to avoid memoriter work in topics not understood, and to keep all experience in mathematics courses from the very beginning a growth in clear thinking.

Academic algebra and demonstrative geometry were written for a select group of men. Until comparatively recent years boys and girls were not exposed to these subjects; they were taught to college people, again a select group of those above the average intellectually. These parts of the mathematics course are being moved forward into senior high school years, because many of the pupils *now* taking secondary education will never find real profit and pleasure in that much abstract mathematics, and because those who are able to do so will find it to a much greater degree at the maturity of at least a tenth or eleventh grader. Again the basic idea for change lies in the determination to provide for development of power to think.

Many of the topics in algebra, geometry, and trigonometry cannot be thoroughly understood by more than an extremely small number of boys and girls earlier than senior high school years. Therefore it is unwise to give a whole year of algebra in ninth grade. On the other hand, there are simple facts and processes in each of those three subjects that can be well presented in junior high school. There is no reason for keeping them in "water tight compartments" from the beginning, and no reason for having a year of algebra before taking any geometry.

Giving introductory algebra, intuitive or constructive geometry, and numerical trigonometry in seventh, eighth, and ninth grades, makes possible a solid foundation for real thinking, real understanding on the part of those who later take courses in higher mathematics. Also such a junior high school course avoids the mistake of denying all knowledge of geometry and trigonometry to those who do not do well in first year algebra, whether this failure is due to immaturity, lack of foundation, or to lack of intellectuality of the type needed for success here. In fact, many who would profit thereby, are given no experience in even the simplest parts of algebra because they could not succeed in a full year of the traditional kind.

A real course in general mathematics takes from arithmetic, algebra, constructive geometry, and numerical trigonometry, those simple elements that can have meaning for youth at the age of twelve, thirteen, and fourteen, and presents them in such a way as to show clearly relationships, to give some glimpse of the whole field of mathematics, and especially to insure interest and pleasure with increase in power to think clearly.

The sixth point referring to the tendency to omit certain topics from each year of elementary and junior high school arithmetic, and to teach some of these with review of fundamentals throughout the years of senior high, give further proof of an awakening. As in the other changes being called for, this, too, shows a recognition that no part of any subject of mathematics should be presented until the maturity and experience of the pupil makes possible its thorough understanding. Then only can its teaching carry out the primary purpose of training in mathematics, *i.e.*, helping to develop a desirable way of thinking.

9. Good drill—meaningful, motivated—*following* understanding.

10. Emphasis on relationships, dependence of one variable

upon another; basic, fundamental principles; forming and strengthening of desirable habits and attitudes; solid growth in clear-cut, logical thinking of value in every circumstance, all of one's life.

11. Laboratory work.

12. Well equipped classroom; tables and comfortable chairs,—no individual desks fastened to the floor; very large bulletin board; a good blackboard space with cross section lines painted on it; plenty of blackboard space; a library; several histories of mathematics; "Number Stories of Long Ago" and "The Wonderful Wonders of One-Two-Three" by David Eugene Smith; a few recreational books in mathematics; a facsimile of "The Rhind Papyrus"; pictures of mathematicians noted in ancient times or modern; slide rules; transit; a circle that falls into triangles, a sphere that falls into pyramids, a cone cut to show the different curves; hollow, non-rust cylinder and cone having the same dimensions; hollow, non-rust rectangular prism and pyramid each with a six inch square base and a height of four inches; models, charts, posters, etc. made by the pupils; board compasses and protractors besides string, chalk, and rulers; also there should be quite a large number of auxiliary textbooks and some magazines: *The Mathematics Teacher*, several others that especially appeal to boys interested in mechanics or other subjects that involve more or less mathematics.

13. Field trips, visits to banks, stores, factories, talks from various forms of business, from professional life, and from teachers of later courses in different fields.

14. A fine degree of mastery, of success and happiness for each and every boy and girl.

The forming and strengthening of good habits and attitudes have been mentioned. On this point there must be a reminder that while the desirability of attaining these should be clearly present in the thought of both teacher and pupils, yet all preachiness must be avoided. There are various tactful, natural pleasant ways to keep the class throughly conscious of this part of good purpose.

Desirable habits and attitudes that may be formed or strengthened in a mathematics class are as follows:—

1. Distinguishing between important and irrelevant factors in any situation
2. Common sense estimation of result
3. Best use of eye and ear in wide-awake, alert attention

4. Exact following of directions
5. Neatness
6. Desire to get to the bottom of things
7. Withholding judgment until sufficient evidence is in
8. Openmindedness
9. Keenness in detecting absurdity of an answer
10. Urge to check or prove everything
11. Unwillingness to neglect the correcting of mistakes
12. Accuracy
13. Speed
14. Sensing of relationships, dependencies
15. Dislike of vagueness, incompleteness, inconsistency
16. Precision of statement
17. Eager search for general law, for basic principle
18. System and order as help in memory and understanding
19. Appreciation of what mathematics has done for our comfort, convenience, and progress
20. Satisfaction in certainty, in self-confidence
21. Joy in discovery, and in independent thought
22. Reverence

Always there have been outstanding teachers of mathematics. They are found all along the line from earliest grades through high school and college. They have been and are well remembered and beloved. Here are a few points that come to mind in thinking of them:

Straighten out the kinks.

Supply the missing links.

Remove "inferiority complexes."

Secure and maintain interest.

Point out the way or lead to discovery of relationships, far-reaching applications, simple, fundamental principles.

Provide plenty of the type of drill that the young people enjoy at the time given, and that they see clearly the reason for the practice, the goal to be desired, and how close they come to it each day.

Emphasize possible forming and strengthening of good habits and attitudes.

Make sure of a fine degree of success and happiness for every boy and girl.

In what various ways can the individual teacher help to improve the situation? One point of vital importance is to feel keenly the responsibility toward improvement of mathematics teaching throughout the country, and to act accordingly. This will be manifest in many ways.

The subscribing for and the reading of SCHOOL SCIENCE AND MATHEMATICS, *The Mathematics Teacher*, the *N. E. A. Journal*,

and one or two other periodicals published especially for teachers, aid greatly toward keeping in touch with important trends and with leaders in the field. Reading, listening, and observing in many other fields of worth-while human endeavor, insure breadth of understanding and appreciation so necessary for a teacher's leadership in the class room, opening doors to ever widening views of not only mathematics, but other worlds as well.

It must not be overlooked that owning and reading as many as possible of the Yearbooks of the National Council of Teachers of Mathematics, and the work of leading educators in good books as they appear, gives more value than is generally recognized as yet.

More than willing attendance at teachers' meetings, committee meetings, conferences, with wide awake eagerness to hear and to be ready to serve in any way called upon is productive of much growth. Intelligent pride in the profession, earnest desire to be in that large group of leaders for its advancement in giving to all boys and girls the very best that is possible, evinces a readiness to make real contribution.

The wide spread criticism of mathematics heard recently, in so far as based upon fact, is not due to lack in the subject itself, but to the faulty methods of teaching. If the viewpoint is of mathematics as a tool subject, the results will continue to be disastrous. But if the viewpoint is of mathematics as a method of thinking, necessary tools will be acquired, well sharpened, less likely to rust, and also, the pupil will have had development in power to think clearly. This will be realized and appreciated throughout later years both by himself and by his associates.

A teacher who is aware of the situation, and who desires to help in improvement, will be alert to do one or more things each term better than ever before. His classroom procedure will be free from both extremes of being in a rut and of following fads without being sure of good results. He will not jump to take up something just because it is called new or the latest innovation, and he fears to be behind the times. Neither will he cling to the use of candles to which he and his ancestry are accustomed, when the greater illumination of electric lights is evident, helping to point the way to solid, joyous development of a desirable "way of thinking."

BOSTON, THE HUB OF NATURE STUDY

Prepared for National Recreation Association

By William Gould Vinal

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I. *In the Beginning Boston was without form and void.* Marvellous changes took place to lay the foundation for the "Hub of the Universe." Before life on land trilobites were supreme. Then liquid rock pushed into the Braintree slates and formed Quincy granite which was later to be hauled over the first railroad to form Bunker Hill Monument. The next event in the story was when the Roxbury giants mixed a big plum pudding for a feast. The huge reptiles must have been astonished to see the giants quarrelling and throwing pudding at each other. Of course, part of this is a fairy tale, but the pudding stone remains as evidence of a true story that is more wonderful than fiction. It must have been exciting when the West Roxbury volcano blew up. But here again there was no one around with enough of a nervous system to get excited. Then came the Ice King, right over the top of Mount Washington. Boston was refrigerated. The glacier dumped island-drumlins including such notables as Beacon Hill, Bunker Hill and Dorchester Heights. It now remained for the sea to rise to form Boston Harbor and to tie such islands as Hull and Nahant to the mainland by beaches. When these awesome chapters were recorded in rock, Nature had finished the main events in the making of Boston. The remainder of the story has to do with man.

Human Documents began in Boston in 1630 by the simple dictum of the court of the Massachusetts Bay Colony "that trimountane shall be called Boston." Tri-Mountane (Tremont) consisted of a peninsula with three hills, the highest being Beacon. The Indian name "Shawmutt" or "Living Waters" was forsaken. The big earthquake of June 1638 was recorded in Bradford's "History of Plymouth." "It was in this place heard before it was felte. It came with a rumbling noyse . . . it came from ye norward, & pased southward . . . as if ye lord would hereby show ye signs of his displeasure." If the Lord was pleased with his first local handiwork—and he might well have been—it was thought by the Puritans that he was displeased with his human children. That did not hinder their descendants from changing the landscape. When the tops of the hills were lowered

to fill the coves and mudflats, Back Bay and much of South Boston, were man-made. The tidal arm of the sea was changed to the Charles River Basin with fresh water. When the springs and wells gave out water was brought from Jamaica Pond (1795), than Lake Cochituate (1848), and then from the Wachusett Reservoir. In 1938 it is necessary to extend the metropolitan water works to the new Quabin Reservoir. So the trilobites, and the volcanoes, and the glaciers, and the Puritans, and the springs, and the most likely landscapes have melted away. Since the red man looked upon the place of "Living Waters," since the Lord showed his displeasure through earthquakes, since scientists have solved the rock puzzle, there has been considerable thinking about Boston's drama of nature. The purpose of this writing is to present this narrative of nature study in simple but condensed form. If Boston is the hub of the Universe in general one of the spokes is nature education. The advance of the study has been long, specialization in nature study has become intense, and retrospect with its implications for the future are prophetic.

II. *The Classical State Reports of Massachusetts.*

George B. Emerson (1797–1881) came from Harvard ancestry. His father, a physician, graduated from Harvard (1784), was chairman of the school committee, and saw that his sons went to school in winter and received a practical education on the farm in the summer. After the age of eight George B. was kept at home and set to work as early in the season as he was needed in the garden. He learned to use every tool and was often told that if he had all the weeds out of a certain bed by such a day that he could go fishing for pickerel or sea-trout. He gathered berries and chestnuts and in spare time read Manassah Cutler's books, Bartram's travels, and Scott's poems. When the last ear of corn was husked he went back to school. "So great were the advantages of my summer's employment that I have, for many years, had no doubt that it would be far better for all the boys in the country towns of Massachusetts not to be allowed to go to school in the summer, but to educate their muscles and form habits of observation and industry by pursuits similar to those which it was my privilege to be engaged in." This sentiment was expressed in his "Reminiscences of an Old Teacher" (1878) which was first printed in the "Journal of Education."

Emerson was graduated from Harvard in 1817. He was chosen first principal of Boston English-Classical School (1821) and

experimented with Warren Colburn's manuscript for the first edition of "Mental Arithmetic." It was Emerson who suggested a survey of the state to Governor Everett and in turn was chosen to present the trees and shrubs. Emerson's book on the "Trees of Massachusetts," a result of nine years of work, is both scientific and literary. In 1837 he was elected president of the Boston Society of Natural History. He was also chosen to deliver the memorial address on Agassiz to the Society (1874).

Augustus Addison Gould (1805–1866) at the age of 15 took charge of his father's farm at New Ipswich. When the farm work had been attended to he went to school graduating from Harvard in 1825 and obtaining his M.D. in 1830. However, he was best known as a naturalist. For two years he taught botany and zoology at Harvard. He also worked on the collections at the Boston Society. He reported on the invertebrates (except insects) for the State Survey of Massachusetts, doing his own illustrating. For years his "Report on the Invertebrata of Massachusetts" (1841) was the only source book and the manual influenced many to take up the study of shells. He was one of the first to consider the geographic distribution of shellfish and stood next to Say in his influence on Conchology. In 1848 he was associated with Louis Agassiz in the preparation of "Principles of Zoology," a small book intended for schools.[1]

Amos Binney (1803–1847) graduated from Brown (1821) and also obtained his M.D. from Harvard (1826). Binney was another authority on shells and was particularly interested in the American land mollusks. Being elected to the legislature in 1836 he was influential in obtaining the state reports which were to be the chief biological and geological source books for years.

Edward Hitchcock (1793–1864), another popularizer of science, was Chief of the Geological Survey of Massachusetts (1830–1841). He won the distinction of being the "father of New England Geology." In 1832 he was professor of Natural History at Amherst College and by 1851 he was president. His State Report is a companion book to Emerson's Trees and Gould's Invertebrates. His Elementary Geology (1840) reached its 31st edition in 1860.[2]

Dr. Thomas Mayo Brewer (1814–1880), Harvard 1835, was

[1] Wyman, Jeffries. Augustus Addison Gould. National Academy of Science Biographical Memoir. Vol. V, pp. 91–113.

[2] Lesley, J. P. Edward Hitchcock. National Academy of Sciences Biographical Memoirs. Vol. I, pp. 113–134.

one of the earliest members of the Boston School Committee to be interested in popular education. He is said to have furnished notes to Audubon and is often mentioned in the ornithologist's great work. Brewer added 45 species to the "Catalogue of the Birds of Massachusetts" in Hitchcock's Report. (1837).

III. *The Three Masters from Cambridge who shaped the destiny of Science Teaching* (Period of 1840–1885).

1. *Asa Gray (1810–1888), Master of the Science of Botany.*

Asa Gray was brought to a botanical consciousness by an article in Brewster's Edinburgh Encyclopaedia. As a result he bought a "Manual of Botany" by Amos Eaton and "waited patiently for spring," though "out of all reach either of a greenhouse or of a potted plant." The next spring he discovered and identified Claytonia. "On an April day, in 1823, I sallied forth into the bare woods, found an early specimen of a plant in flower, peeping from dry leaves, brought it home, and with Eaton's Manual, without much difficulty, ran it down to its name, Claytonia Virginica. I was pleased at my success and went to collecting and examining all the plants on which I could lay my hands, and the rides over the country with my preceptor in visiting patients gave me good opportunities. I began an herbarium of shockingly bad specimens."[3]

Gray was next influenced by Dr. John Torrey, professor of chemistry in the College of Physicians and Surgeons in New York. Both Gray and Torrey taught Chemistry but were interested in Botany.

During the summers of 1832 to 1834 he botanized successively down the Unadilla, along the New Jersey Pine Barrens, and the Black River.

His visit to Europe (1838) enabled him to meet distinguished naturalists such as De Candolle, Hooker, and St. Hilaire. He had the confidence of Darwin who sent advanced copies of the "Origin of Species" to Gray, Hooker, and Lyell. Because he boldly accepted Darwinism (1859) he was considered an atheist.

Gray's most notable publication was his Manual (1848), his 6th edition appearing in 1868 and the seventh edition was rearranged and revised (1908) by his successors, M. L. Fernald and B. L. Robinson. His work brought the contributions of

[3] Goodale, George Lincoln. Sketch of the Life and Work of Asa Gray. Proc. Bos. Soc. Nat. Hist. Vol. 24, 1889, pp. 191–198.

Nuttall, Michaux, and Pursch under a standardized system. His geographic notes marked the beginning of geographical botany. He once quoted George Bentham who said that "the aptness of botanical description, like the beauty of a work of the imagination, will always vary with the style and genius of the author." "Gray's Manual" is a standard of scientific description.

Gray came to Cambridge in 1832. His home in the Botanic Garden was once occupied by Nuttall. He gave forty-five years of devoted work to Harvard.

Gray's first textbook was the "Elements of Botany" (1836)[4] in which he had the courage to break away from the artificial system of the great Linnaeus and base it on the natural system of De Candolle. In it he recognizes not only structural botany but the physiological and systematic phases and speaks of excitability. It is a remarkable book and the beginning of a series for young folks. George B. Emerson's autographed copy was presented to the Boston Society of Natural History in 1877.

Gray's "Botany for Young People," Part I, "How Plants Grow" (1858, page 233) (1864), and part II "How Plants Behave" (1872) show how a systematic botanist can describe in simple clear language which is the true test of a great master. Part I is well illustrated with 500 wood engravings and ends with a "Popular Flora" for beginners according to the natural system of common wild and cultivated plants. It is interesting to quote from the introduction which was written as long ago as 1858. "Interesting as this study is to all, it must be particularly so to young people. It appeals to their natural curiosity, to their lively desire of knowing about things. . . . To learn *how to observe* and how to distinguish things correctly is the greater part of education. . . . Natural objects, everywhere present and endless in variety, afford the best field for practice. . . . This study ought to begin even before the study of language. . . . This book is intended to teach young people how to begin to read, with pleasure and advantage, one large and easy chapter in the open Book of Nature."

2. *Louis Agassiz (1807–1873), Master Teacher of Natural History.*

Agassiz was born in a Swiss parsonage in view of the Jungfrau and other Alpine summits. He said "I lived three years under Dollinger's (pioneer embryologist) roof and my scientific train-

[4] Gray, Asa. "Elements of Botany." G. and C. Carvill & Co. 1836, p. 428.

ing goes back to him and to him alone." Agassiz so won the affection of Cuvier (Father of Comparative Anatomy) in Paris that Cuvier turned over his materials and notes on fossil fishes. Humboldt helped Agassiz financially and obtained him a professorship in Natural History at Neuchatel (1832) where he began his teaching. Here, over a century ago, Agassiz took little folks on field trips and when the class stayed indoors he gave every child a specimen.

The summer of 1836 was spent near the home of Jean de Charpentier. Agassiz startled the world when he advanced his theory of a universal glacial epoch (1837) or "Ice Age" as it was called by Karl Schimper. This led to the "Hotel des Neuchatelois" (1840) being built on the medial moraine of the lower Aar glacier. The "Hotel" had a blanket door and a boulder roof. It was at this time that the motion of the ice was studied by placing a line of stakes across the glacier. His mother characterized his being lowered by a rope into a glacial crevasse as "Louis's descent into Hades." His "Etudes sur les Glaciers" (1840) appeared in two volumes.

In a few years Agassiz came to America (1846) where his enthusiasm became contagious. The *Evening Traveller* (1848–49) printed his lectures in full. At various times he had 23 naturalists working in his home, who, with one exception, came from Neuchatel. Agassiz characterized the new world as "a land where Nature was rich, but tools and workmen few and traditions none." He attracted many student disciples. Even Emerson thought that "something should be done to check the rush toward natural history."

Doctor Gould introduced Agassiz to George B. Emerson. That afternoon Emerson took Agassiz in his chaise to see some hickories. Agassiz had seen fossil Carya in the Jura Mountains and was anxious to see a growing stand. Agassiz had never been on a sea beach before except the fossil beaches in the Jura Mountains. Emerson says "What a trip."[5]

In Cambridge Professor and Mrs. Agassiz opened a school for young ladies (1855). He gave an hour's instruction each day. He had them hold grasshoppers and opened their eyes to methods of teaching.

Agassiz' summer school of science at Penikese (1873) stressed the "Study of Nature, not books" which has become a much used motto. From this school originated the idea that nature

[5] Emerson, Geo. B. "What we owe to Louis Agassiz as a teacher." Boston. 1874.

study in the elementary schools should be better than memorizing. In the dining room there was a blackboard where Agassiz often demonstrated blackboard teaching. An intellectual feast often was carried on simultaneous with the physical feast. One of the portraits of Agassiz most often seen shows his ready use of chalk.

Undoubtedly there are many who would welcome the gist of what Agassiz said at Penikese. I am therefore presenting a brief of his first words to the students (July 9, 1873). "Ladies and Gentlemen: Were I about to teach a class in the ordinary sense I should make a very different beginning. My intention is not, however, to impart information, but to throw the burden of study on you. . . . I must teach and yet not give information . . . . Do not ask them (questions), for I shall not answer. You may have seen a gravelly, water-worn neck of land. . . . What is the meaning of the curve? Of the loose materials? Of the boulders? If you could answer me in two months. . . . I would say you have indeed done well. . . . And this mode of teaching children is so natural. . . . That is the charm of teaching from Nature herself. You will find on this small space (Penikese Island) three-fourths of all the rocks in the United States. I would advise you to begin by collecting rocks."[6]

Professor Agassiz was deeply conscious of the essentials of learning and of the art of teaching. He believed that a teacher must know some one thing well, that the pupils must hold specimens of common things and be led to observe. He emphasized that there should be "a little museum in every school room."

Agassiz also thought that there were sufficient reasons why "the study of Natural Science may be made the real foundation of all education" and lamented that the study had been neglected in the common schools. It is clear that he considered that nature study included the external characters of minerals, plants and animals. He believed that this elementary study should be substantial and would "decidedly avoid speaking first of classification." He suggested for example a comparison of man with a living dog, later a bat, and then a hen in a cage. And "to see it every day, would be, in my opinion, far preferable for the instruction of the young, to the most wonderful parrots . . . of the tropics. It is very unwise . . . to allow the horror . . . of the

[6] Agassiz, Louis. Lectures delivered before the Anderson School of Natural History on Penikese Island. July and August, 1873. Compiled from Notebooks of Students for "The Tribune" (N.Y.) Jan. 29, 1874. Also pamphlet edition No. 9.

rattlesnake . . . to be transferred to those pretty, harmless and even beautiful varieties which feed in our gardens. . . . But the great thing . . . is not the meagre accounts which are found in our elementary books, but the living nature itself."[7]

And Agassiz was perfectly conscious of the lack of books when he referred to the state reports, Harris' Insects, Gould's shells etc. as reading books. He spoke of the need of picture books and no doubt would have been delighted if he could have seen the great avalanche of wonderfully illustrated books that have been bestowed upon us today. Agassiz's wish was a prophecy. He was more than "three score year and ten" ahead of his time.

Agassiz's grave at Mount Auburn is appropriately marked by a boulder from the Aar glacier near Hotel des Neuchatelois and shaded by pines from the Swiss Alps. On the boulder appears the apt but cryptic phrase, "Louis Agassiz, teacher."

3. *Arnold Guyot (1807–1884) Master of Teaching Elementary School Geography.*

Guyot, like Agassiz, lived as a child amidst the beautiful surroundings of the Swiss Alps. He also profited by association with Alexander Braun, Karl Schimper, and Louis Agassiz. When Guyot attended the lectures of Carl Ritter he decided to leave theology and pursue nature-science. He also was acquainted with Alexander Von Humboldt who was the "first to suggest the graphic method of representing natural phenomena . . . the first geological sections, the first sections across an entire continent and the first averages of climate illustrated by line." (p. 5)[8]

Guyot was called to the chair of history and geography at the Academy of Neuchatel (1839–1848). When Agassiz read his paper on the glacial theory before the Society of Natural Sciences at Neuchatel he urged Guyot to visit the glaciers. Guyot spent six weeks on the glaciers the next year (1838).

At the suggestion of Agassiz he came to Boston (1848) and delivered a course of lectures in French at the Lowell Institute (Free public lectures since 1840.) These were translated and published under the title "Earth and Man." The book was a

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[7] Agassiz, Louis. The Massachusetts Teacher. Jan. 1850. Vol. III, No. 1. Louis Agassiz, Editor of this Number. Main article entitled "Importance of the Study of Natural History as a Branch of Elementary Education."

[8] Agassiz, Louis. Address delivered on "The Centennial Anniversary of the birth of Alexander Von Humboldt" under the auspices of the Boston Society of Natural History. 1869.

reflection of the ideas of Ritter. Guyot lived in the home of Agassiz. Guyot was soon employed by the Massachusetts Board of Education to lecture on methods of instruction in geography to Teachers Institutes and to Normal Schools (1848–1854). He often had audiences of 1500 teachers. These lectures led to the preparation of a series of books on geographic teaching (1861–1875) which made the study something more than statistics and localities. As was true of his friend Agassiz, he believed that nature and not books was the starting place. He emphasized the use of topographic maps. His method of instruction was: observation in the field, accumulation of facts, and statement of principles as based on evidence. He recognized orderly progress as did Agassiz which is now called evolution. He knew the "Geographical March of Human History" which was later to be emphasized by Ellen Sample. He considered America a land of "liberty and equality." His books were practical and were models for geography teaching for generations.

Aggasiz might have said of Guyot as he did of Humboldt that "every school-boy is familiar with his methods now, but he does not know that Humboldt is his teacher." (p. 5)[8] These two friends from Switzerland, Agassiz and Guyot, performed a service to American Nature Study—a combination of science and education—which can scarcely be equalled.

IV. *Disciples of Agassiz Who Influenced Boston Natural History.*

There are several disciples of Agassiz, all born within five years of each other, who had a profound influence in carrying over his attitudes and traditions. They were mostly in the famous class of 1862, Harvard.

Alexander Agassiz (1835–1910), the son of Louis, came to America at the age of 13 and graduated from Harvard when 19. In 1860 he was made assistant in the Museum of Comparative Zoology. He established a seaside laboratory at Newport which was opened to instructors and students from Harvard. He made numerous voyages. The first section of the Museum of Comparative Zoology was erected in 1859 and additions were made possible by Alexander Agassiz.[9]

Alpheus Hyatt (1838–1902) graduated from Harvard in 1862. In the class were Verrill, Packard, Shaler, Scudder, Theodore Putnam, Morse, A. Agassiz, A. S. Bickmore and J. A. Allen,

[9] Goodale, George L. Alexander Agassiz. National Academy of Science.

Hyatt learned Agassiz's "Essay on Classification" by heart.

According to Tarr his most useful work was on popular science teaching. (p. 264)[10] He taught his pupils to observe and think as the Master Agassiz had taught him.

Number 8 of his "Guides for Science Teaching" is on "Insects"[11] and is a model of simplicity. In the Introduction he says "This Guide is a series of replies to questions which have arisen in the minds of its authors while teaching." He was also a true devotee of Agassiz when he said that "Specimens . . . are nature's own books." He used the grasshopper as a type. Hyatt rendered science popular and Tarr was referring to Hyatt when he wrote that "Those who are doing their best to render science popular are doing far more for true science than those who purposely shun such work and confine themselves to uninteresting and often unimportant problems." (p. 267)[10]

Hyatt's "Guides" evolved from his work with the Teachers School of Science. He carried Agassiz's methods to 1200 teachers who in turn carried the example unto their children who were pedagogically the fourth generation. Brooks says that Hyatt ranks with Agassiz and Huxley as a teacher.[12]

Hyatt and three of his classmates—Morse, Packard and Putnam—were made curators of the Peabody Academy in Salem. They also instituted and were the first editors of the American Naturalist.

Hyatt was Professor of Zoology at Massachusetts Institute of Technology for eighteen years (1870–88), was on the staff at Boston University for twenty-five years (1877–1902), and carried on at the Boston Society of Natural History thirty years (1870–1902). He lived in Cambridge so as to study his Cephalopods at the Museum of Comparative Zoology. He founded the Annisquam Marine Laboratory (1879) but later abandoned it to back the Wood's Hole laboratory. The Hyatt Memorial Fund was raised by a subscription which showed the appreciation of his followers. The income was to be used annually to transport Boston children to the country.

Edward S. Morse (1838–1925). At the age of 13 Morse had a collection of shells. He was at Agassiz's school 1859–1862. He

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[10] Biog. Memoirs, Vol. VII. p. 289–305. Tarr, Ralph S. Pop. Sci. Mo. Vol. 28, No. 2, pp. 261–267, Dec. 1885.

[11] Hyatt, Alpheus and Jennie M. Arms. Insecta 1890, 1898. 300 pp. Boston Society Natural History, D. C. Heath and Company.

[12] Brooks, William K. "Biographical Memoir of Alpheus Hyatt." Washington 1908. 15 p. Read before National Academy of Sciences, April 23, 1908.

graduated from Harvard with Hyatt and must have been rated high by the Master as he was then appointed assistant at the Museum (1862–1866).

The writer remembers Morse's boyish enthusiasm in a game of tennis at Wood's Hole in 1914. At his lecture in the evening he was full of humor. He told about the hair on the forearm extending toward the elbow as in the apes. He said—"If you don't believe it ladies look and see when you get home."

Morse was an authority on Japanese Pottery and in reminiscing told about picking up a stone in Japan and how the dogs turned around to see what it meant. He then said, with a twinkle in his eye, pick up a stone in good Christian America and see what happens. He sketched butterflies on the blackboard using both hands at once. The audience was so extensive that there several crowding about the windows on the outside which pleased Morse immensely. He possessed rare qualities as a popular lecturer.

At his home in Salem when he was in the middle eighties I recall finding him studying arrow release by primitive tribes with the same unbounded enthusiasm that he played tennis. Brachiopods were regarded as Mollusks until he discovered through embryology that they should be classed with worms.[13]

Morse was very fond of children and his "First Book of Zoology" (1875) was one of the earliest texts in zoology written for young folks. 158 of the 321 illustrations were line drawings by the author. It was published by D. Appleton and was reprinted in London and translated into Japanese.

Biographical primers of our science heroes should stand along those of our war heroes. The biography of Morse would be both interesting and instructive in peace time arts and international relations and good will.

Samuel H. Scudder (1837–1911). Scudder was born in a gardenless house in Boston but when ten moved to the country (Roxbury) to a thirty acre farm.[14] At sixteen he went to Williams College in the Berkshires where his elder brother David was attending. It was here that he saw a box of butterflies artistically arranged. This so stimulated him that he started a collection. He joined the College Lyceum which was a Natural History Society and became one of the leaders in the "Alpine Club of Williamstown."

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[13] Sketch of Professor E. S. Morse. Pop. Sci. Mo. Vol. XIII No. 73. May 1878.

[14] Scudder, Samuel H. "How I served my Apprenticeship as a Naturalist." Youths Companion, Nov. 5, 1896.

Scudder then studied with Agassiz for four years (1858–1862). "In the Laboratory with Agassiz" appeared in "Every Saturday," April 4, 1874. It is a memorable story and I quote from it freely. Scudder entered Harvard to study insects but Agassiz gave him a fish. The student looked at the fish for hours. Finally—at the depth of despair—a happy thought came. He decided to sketch the fish. Agassiz returned, listened, but seemed disappointed. The afternoon passed more quickly. The next morning he said to the Professor: "Do you perhaps mean that the fish has symmetrical sides with paired organs?" Agassiz's thoroughly pleased "Of course, of course" repaid the student, but he was again left to look at the fish. And so on for three long days. "This was the best entomological lesson I ever had" Scudder goes on to write, and "at the end of eight months, it was almost with reluctance that I left these friends and turned to insects."

In giving advice to young entomologists he said in true Agassiz style "It is not well to begin with many books . . . the best single book is Harris's 'Insects Injurious to Vegetation,' the illustrated edition."[15]

Scudder wrote popular books such as "Trail Children of the Air," "Excursions into the World of Butterflies" (1895), and "Everyday Butterflies" (1899). His "Butterflies of the Eastern United States and Canada" (3 volumes) was the result of thirty years of research. It is technical but has popular essays on migration, protective coloration and distribution. He quoted from poetry, proposed popular names for 77 species of American butterflies, and discovered the White Mountain butterfly which was stranded during glacial days on the islands of Mt. Washington and Pikes Peak.

Charles Otis Whitman (1842–1910). Whitman graduated from Bowdoin in 1868. He taught in the English High School, Boston (1873–1875) where he "distinguished himself by his original methods in teaching certain branches of elementary science." (p. 274)[16] He attended Morse's classes at Penikese, was assistant in Zoology at Harvard (1883–1885), succeeded Morse at the Imperial University in Japan (1880–81) and was first Director of the Marine Biological Laboratory at Wood's Hole (1888–1908).

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[15] Scudder, Samuel H. "The Young Entomologist and what he wants." "Independent," July 16, 1896.

[16] Morse, Edward S. Charles Otis Whitman. Nat. Acad. Sci. Biog. Memoirs. Vol. VII, pp. 269–288.

V. *The Boston Society of Natural History, A Coordinating Influence.*

Among the early efforts in Natural History were those of Dr. Benjamin Waterhouse of Harvard who published a pamphlet entitled "Heads of a Course of Lectures on Natural History" (Cambridge, 1810). He spoke of such titles as Ornithology, Amphibiology, Ichthyology, Insects and Vermes as "outskirts of animated nature extending to the confines of the vegetable world." The good gentleman added a note saying that he would "extend, contract or omit parts of his programme to suit his audience" which was probably open to the public as had been the case of one of his first courses at Brown.

Professor W. D. Peck occupied the chair of Natural History at Harvard College (1805–1822). Dr. A. A. Gould said that "He gave such instruction as was demanded which was very little." (p. 3)[18]

The American Academy of Arts and Sciences was formed in 1780. It is the second oldest scientific society in America. Its building, a memorial erected to Alexander D. Agassiz (1912), houses a 4000 volume library. Its membership is by invitation, consisting mostly of professors from Harvard and Technology. The first volume of Memoirs appeared in 1785. In the third volume (1809) there was an article on geology of the vicinity of Boston by Monsieur Godon who took his class on field trips. (p. 6)[17]

A number of gentlemen met at the house of Dr. Jacob Bigelow (Dec. 8, 1814). Among the honorary members were Rev. Manassah Cutler and Rev. J. T. Kirkland. Among the Corresponding Members we find such familiar names as Josiah Quincy, Professor Benj. Silliman and Dr. E. Hale, Rev. Wm. Ellery Channing and Rev. Edward Everett were listed as Associate members. (p. 5)[18] In contrast to some other communities the society not only from the beginning had the sanction but enjoyed the membership of the free thinkers in the clergy.

For over a century the Boston Society of Natural History, the second oldest in America, attracted men of ability and distinction (1830). Many of the members worked at their profession during the day and played with their collections before and after work. The narrative is one of devoted zeal and volun-

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[17] Warren, M.D., John C. President of the Society. An address before the Boston Society of Natural History. 1853.

[18] Bouve, Thomas. Bos. Soc. Nat. Hist. Anniversary Memoirs. (1830–1888).

tary labor. Thomas Nuttall (1786–1859) was elected the first president but declined as he considered himself a transient resident. Audubon became a member in 1832 and the society subscribed to his "Birds of America."[18] Through the combined efforts of the members American Natural History was raised out of obscurity, books were no longer limited to foreign make, and a local effort in elementary nature education was born.

The *Teachers School of Science* of the Boston Society of Natural History (1870) was a unique institution in its day and was a forerunner of university extension for teachers in elementary science. It was founded by Alpheus Hyatt who was its curator until his death in 1902. Dr. Samuel Eliot, Superintendent of the Boston Public Schools, said at the Semi-Centennial Celebration (1880)[19] "I think, as I stand here, of the scenes that I have looked upon in this and the adjoining building (Rogers Hall of Mass. Institute of Technology and now a Boston University building) where the teachers in our public schools have gone at the invitation of this Society and through individual genius and the teachings of the friends of this Society have received lessons which they in their turn have given to their children. And when I think of all that this involves of *nearness to Nature, which forms so true an essential of education*, and which, without such help as this Society has given would be today little more than a name among our teachers and pupils."[20]

A catalog of the *Teachers School of Science* with a list of the faculty and their subjects is a notable compilation of cooperating naturalists that few communities could parallel.

Teachers School of Science

Name of Instructor	*Institution Connection*	*Course Given*	*Year*
Prof. Wm. H. Niles	Mass. Inst. Tech.	Physical Geog. 33 lessons	1870
W. C. Greenough	Providence Normal	Mineralogy	1870
Alpheus Hyatt	Mass. Inst. Tech.	Zoology	1870
W. G. Harlow	Harvard	Botany	
L. S. Burbank		Mineralogy 30 lessons	1871
Geo. L. Goodale	Harvard	Botany 21 lessons	1876
Wm. O. Crosby	Mass. Inst. Tech.	Common Minerals	1876–1889
W. M. Davis	Harvard	Physical Geog.	1886–1898
F. W. Putnam	Peabody Museum, Harvard	American Archaeology	

[19] Bos. Soc. Nat. Hist. Milestones (1830-1930).

[20] Zirngiebel, Frances. Teachers School of Science. Appletons' Popular Science Monthly. August 1899.

Geo. H. Barton	Field Geology	1887
A. W. Grabau	Shore Animals	1897

Boston Society of Natural History—A Few Distinguished Members

Members	*Curator*	*President*	
Geo. B. Emerson	1830–1837	1837–1843	Original Member
Amos Binney	1830–1832	1843–1847	Original Member
Augustus A. Gould			
Jeffries Wyman		1856–1870	
Alpheus Hyatt			
Samuel Scudder	1859–1870	1880–1887	
Geo. Lincoln Goodale		1891–1892	
Edward S. Morse		1914–1920	
Louis Agassiz, Honorary Member 1837			
John James Audubon (1832) Honorary Member 1841			
Spencer F. Baird			
Alexander Graham Bell			
Chas. W. Eliot			
Ralph Waldo Emerson			
Oliver Wendell Holmes			
Horace Mann			
Henry D. Thoreau			

The courses of 1870 were attended by 55 to 600 elementary school teachers. In the fall of 1871 John D. Philbrick, Superintendent of Schools, appointed a Committee of School Principals. A circular was sent to the teachers announcing lessons to be given by "professors familiar with the object lessons of teaching and skillful in the use of chalk."[16] The funds were provided by John Cummings. 700 teachers responded. Materials were considered important and were distributed at the lectures. Marine animals were furnished by S. F. Baird, U. S. Commissioner of Fisheries, plants through the generosity of Asa Gray and mineral specimens by L. S. Burbank. In 1876 there were 100,000 specimens distributed to 616 teachers. Some of the teachers must have approached the "dignity of scientists" as this year women were admitted to the Boston Society. It was at this time that Lucretia Crocker, Supervisor of Nature Study, introduced the study of nature into the Boston Public Schools.

Notable pamphlets were issued by Messrs. Ginn and Heath. Hyatt's "About Pebbles," Goodale's "A Few Common Plants" and Hyatt's "Commercial and Other Sponges" appeared.

No. IV of the "Guides for Science Teaching" was entitled "A First Lesson in Natural History" (1879). by Elizabeth Cary Agassiz. Mrs. Agassiz in a frontis-note says that "These Natural History Stories for very young children were written twenty years ago (1859) under the direction of Professor Louis Agassiz, and owe to his guidance any merit they may possess." The

stories are "true" but in narrative form. The first one is about "sea-anemones and corals" and they are classed as Polyps rather than plants or insects as had been done by earlier authors. The book also has the story of the "Hydroids and Jelly-Fishes," and "Star-Fishes and Sea-Urchins." There was a long lapse of time from Mrs. Agassiz's first reader on "radiates" to Edith Patch's "Seashore Children."

In the early 1880's Professor Hyatt's Seaside Laboratory at Annisquam opened from June 5 to September 15 to meet the needs of teachers. Twenty-two students enrolled. It continued for seven consecutive summers and was a forerunner of the Marine Biological Laboratory which was founded at Wood's Hole.

The teachers in Professor Putnam's class became so enthusiastic that they raised a subscription which made it possible to purchase the Serpent Mound in Ohio. Four year intensive courses began in 1891. They consisted of notebooks made from laboratory lessons and field work. Tests were given and diplomas awarded.

Professor George H. Barton was "a teacher of teachers . . . a crusading missionary of science . . . an apostle of the scientific habit of mind." (p. vii) Professor Barton's field trips to type localities were outstanding experiences in observation and discussion. Each study was followed by a general lecture and the notes were handed in as a final exhibit. The course included such topics as erosion, drumlins, rivers, peneplain, glacial structures, and eruptive rocks. This led to more distant excursions such as Nova Scotia (1894), Yellowstone, and the Lake Superior Copper Mines. The Barton Chapter of the Agassiz Association was an outcome where members gave papers at weekly meetings.

The "Teachers School of Science Association" was founded in 1901 with Arthur C. Boyden, President. The vice-presidents were Sarah Louise Arnold and Mary F. Thompson. Professor Barton soon became director of the school and president of the Association. The "Science Teachers Bureau" organized out of this group in 1909 to exchange ideas and materials. Professor Barton died in 1933.

Leadership training in field natural history is needed more today than in the half century of the Teachers School of Science. There have been sporadic attempts. In 1896 there was a Summer School in Wellesley, Massachusetts, in which Natural

History Courses were conducted by Mr. A. P. Morse, Curator of the Zoology Museum at Wellesley College. An announcement was issued for teachers who felt the need of practical information and for those "desirous of combining recreation with the pursuit of knowledge." No preparation or previous knowledge was required. There were two courses: I. Collection and Identification of Animals—progress depending on individual effort and one could devote his whole time to it. II. Bird Study. In later years there have been field courses offered in summer sessions of neighboring colleges and in scout training courses. The Teachers School of Science with its eminent leaders and rich offerings has never been equalled in Boston or anywhere else. What is needed is the devotion and zeal of a Hyatt or a Barton.

(*To be concluded in a later issue*)

PARACHUTE DOCTORS

Swedish doctors serving in Lapland, already used to flying to their patients, are learning how to make parachute jumps in order to reach sufferers more quickly in the event of emergencies.

Previously the best they could do in a pinch, when a request for aid came in, was to instruct the persons who called for help to mark out emergency landing fields (particularly at night) with bonfires and torches. The pilot and radio operator of the plane served as stretcher bearers. The new trick of jumping to reach their patients will save precious minutes and at the same time still enable the plane to land to pick up later any cases requiring hospitalization.

REINDEER PARK RADIO

Canada is erecting a radio station in its 15,000-square-mile reindeer reserve just east of the mouth of the MacKenzie River in the Arctic to keep its men in this isolated area in close touch with Ottawa.

The station, it is announced, will operate on a frequency of 4,324 kilocycles and will have a windmill generator to supply it with power. Aklavik, at present the nearest point with a radio station, is 75 miles by boat and dog team from the reserve. The reserve is 3,000 miles from Ottawa.

SHEEP-KILLER

The puma or mountain lion, largest of temperate-zone American cats, has a much worse reputation as a man-stalker than it really deserves. It has a vast curiosity, and will follow a man for long distances, but it is exceedingly difficult to find really well-authenticated cases of attacks on human beings by this animal. It is a scourge to livestock, however, particularly to sheep, and for this reason it is mercilessly hunted on the Western rangelands.

A CENSUS OF SUMMER GARDENS IN NEW YORK CITY

By Marvin M. Brooks, *Director of School Gardens*
AND
Fred M. Schellhammer, *Supervisor of School Gardens, New York, New York*

That our school gardens should function as laboratories for the city child is conceded as one of the chief reasons for the existence of these gardens. The actual produce value of these laboratories is of secondary concern, important only inasmuch as it represents the culmination of the project in which the child has engaged. With this in mind it is evident that the ideal school garden is one in which there is an abundance of "realia" which, in this case, would mean a large variety of plant life. Each of these varieties of plant life should present some new adaptation of growth for the child to witness and understand. The garden which can offer many different types of plant growth, as well as different varieties, is the ideal garden laboratory. For example, it is more desirable, if one were selecting two vegetables for growth, to select the tomato and the beet rather than the pepper and the tomato or two root plants.

With this in mind, a census of the plant life in 151 of the gardens receiving summer care in the City of New York was undertaken. These gardens represent 55% of all the school gardens in New York City. (Mr. Van Evrie Kilpatrick, founder of the school gardens in New York City and executive vice-president of the School Garden Association sponsored the census.)

In a questionnaire answered by the teachers in charge of each garden the following information was gathered concerning the "realia" in the gardens.

1. Plants of Food or other Utility Value.
2. Annual and Perennial Flowers.
3. Trees.
4. Shrubs.
5. Other Garden Features. (Pools, bird houses, baths, etc.).

It is realized, of course, that there are many other features that are to be found in the garden laboratories. For it is here certainly that the child sees, in a natural environment, the balance in nature. He sees the robin pluck the cherry from the tree, the bee pollinate the flower, and the beetle destroy the

foliage. He learns that, just as each plant has insect enemies, so too do the other living forms in the garden have enemies. The ideal census of all the equipment of our garden laboratories should perforce, include all the life to be found in it. It is hoped that, at a later date, some data of this typc may be obtained. The present study was limited to the five items listed above.

Summary and Findings

As might be expected, in a survey of gardens characterized by different locations and differences in size (the gardens range from 200 square feet to over half an acre) there may be found, in the school gardens a range of varieties, both vegetable and flower, that gives a listing which seems to read like a seedman's catalogue. A check on the flowers listed as growing in the school gardens with a popular garden-flower guide book reveals that over 50% of the flowers enumerated in the guide are grown in the school gardens.

Of the 151 gardens surveyed only 13 were devoted exclusively to flowers. The remaining 138 had space devoted to a vegetable as well as a flower garden. The minimum number of plant organisms supported in any of these gardens was seven in a garden of less than 200 square feet. The maximum number of plant organisms supported in any of these gardens was one hundred and twenty-five varieties in a garden of 2,500 square feet.

The answers to the fourth and fifth queries of the questionnaire indicate that, in the larger gardens, trees and shrubs are also planted. Additional garden features such as rock gardens, bird houses and baths, sun dials, and lily ponds are found occasionally. Three of the gardens have herb areas. One school garden has a memorial planting for a small boy who gave his life in an effort to save a friend. Several have trees planted as memorials to faculty and students of the school.

A study of the returns brings clearly to view the fact that there is no "average" garden. The returns indicate that each garden has developed according to the needs and interests of the community. Yet, on the basis of the tabulations, the writer will risk a description of an "average" garden. Such a garden is 2,500 square feet in area. It contains nine common vegetables and one which is unusual to the city child. It contains seven annual flowers and, in addition, three perennials. The "average" garden does not contain trees within the garden area although trees are to be found on adjacent lawn areas. Garden features,

such as bird houses, etc., are not general in the school gardens.

The following represents a summary of the "realia" to be found in a school garden. It is, of course, of little significance to give a tedious listing of plants and percentages on the gardens containing these plants. It seems desirable, however, to give a summary of the materials found commonly (over 50% of the gardens), those found less often (under 50%), and those found rarely (under 10%). The common, rather than the botanical names are used.

1. *Plants of Food or Utility Value:*

Commonly: Beans (bush), Beets, Carrots, Corn (several varieties), Swiss Chard, Radish (several varieties).

Less Often: Tomatoes, Peppers, Squash, Cucumber, Melon.

Rarely: Cabbage, Eggplant, Kale, Okra, Mustard, Potato, Peanut, Rhubarb, Sugar, Cotton, Alfalfa, Barley, Buckwheat, Oats, Popcorn, Rye, Wheat.

2. *Flowers, Annual:*

Commonly: Allysum, Cosmos, Calendula, Marigold (several varieties), Petunia, Portulaca, Zinnia.

Less Often: Ageratum, Aster (several varieties), African Daisy, Nasturtium, Snapdragon, Sunflower, Four O'Clock, Larkspur.

Rarely: Balsam, Cockscomb, Nicotina, Kocia, Coreopsis, Sweet Pea, Stock, Castor Plant, Salvia, Verbena.

Flowers, Perennial:

Commonly: Iris, Funkia, Phlox, Hollyhock.

Less Often: Aster, Chrysanthemum, Delphinium, Pinks, Lily (several varieties).

Rarely: Yarrow, Columbine, Bleeding Heart, Foxglove, Baby's Breath, Lavender, Peony, Poppy, Cone Flower, Scabiosa, Tritoma.

3, 4. *Trees, Shrubs, Vines:*

Inasmuch as none of these were general to a large group of the gardens, it was deemed advisable merely to indicate the types found. Fruit trees such as cherry, pear, apple, peach, fig, and plum are found in some gardens. Birches, oaks, willows, and maples are represented as well as members of the coniferous group. Dogwood is also found. Among the shrubs are the flowering almond, azalea, butterfly bush, spirea, forsythia, rose of sharon, privet, and honeysuckle. Rhododendron, snowberry, and lilac are also found.

5. *Garden Features:*

Features of the garden other than plant life consist of bird baths, houses, arbors, and trellises. Fish and lily ponds, cold frames, and garden furniture are in some gardens. On the whole, however, garden features were not common to the gardens surveyed.

Conclusions

From the data obtained in the present survey the following inferences are drawn.

1. It would be rash as well as difficult to portray an average garden. The individuality of the specific gardens becomes apparent from a study of the questionnaires. The variety of gardens seems an indication that the various interests and ambitions of the individual school and community, along with attendant physical features of the garden, determine the set up of each garden. It is apparent that certain gardens which now appear to offer far too few varieties of plant life for educational value would be improved if there were a standardization of the "realia" for the garden. By far the greater number would, however, lose their originality. It might be advisable to encourage a "minimum" number of varieties which could be predicated on the average garden as portrayed in this study.

2. In reviewing the type of vegetables listed as grown in the gardens it should be noted that root crops dominate the group. Though the pod variety is represented by the bean, it is suggested that a fruiting type of vegetable also be considered. The tomato and pepper are common varieties which do not have adequate representation in the school garden.

3. Though almost every food plant is grown in one or more of the gardens it is evident that the growth of the grains and other plants mentioned under rarely grown plants of food value should be encouraged to a greater extent. There is, of course, every justification for growing plants common to the child's everyday life. Yet it seems reasonable to suggest that an observational portion of the garden laboratory be reserved for the growth of plants exotic to the child's environment. The correlation of this work with other curricular subjects seems self-evident.

4. Almost every conceivable type of garden feature is listed as being present in one or more school gardens. Yet the frequency of such listing is not great. It is suggested that the addi-

tion of such features as bird houses, baths, etc., will do much to present the picture of balance in nature which the garden attempts to achieve.

The present survey indicates clearly the diversity of plant forms to be found in a city garden. Even those gardens which support a minimum of plant life are doing much to make the child conscious of the cycle of living things. The addition of many varieties of plant life to the garden is simply a means of enriching the principles that may be gathered from the study of the life cycles of representative organisms. Further, when the varieties of plant life are labeled, as they are in many of the gardens, the enrichment of the child's life is obvious. It seems axiomatic that the school garden should possess a diversity of plant forms.

WHAT HIGH SCHOOL STUDENTS LIKE AND DISLIKE ABOUT CHEMISTRY

By
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and
Ernest B. Wilson
Erasmus Hall High School, New York City

Growing out of an increasing skepticism as to the transfer of training, there has been a vigorous attack in recent years on the laboratory method in high school chemistry. Arguments against the laboratory have purported to show its cost, its inefficiency in instruction, its wastefulness as to time, and, indeed evidence has been brought forth showing that knowledge of chemistry may be produced with equal or superior effectiveness through use of the demonstration.

This article, based on a study of student opinions in certain New York City schools, admits the validity of certain of these claims, but offers a different thesis in support of "chem lab,"—for the few, if not for the many. It is not necessary to argue that all high school students should "take" chemistry in order to discuss the essentials of technique for the treatment of those who do include the subject in their curricula.

Nevertheless, it is true that the number of high school students enrolling in chemistry courses is disappointingly small. In

an age of science, we are told, man's appetite for knowledge of scientific facts should be considerably sharpened. Yet in spite of its importance, chemistry has not made significant progress in enrolling pupils. Nor has its achievement in acquiring repute as an instrument of instruction in useful scientific knowledge been startling. School surveys and studies indicate that fewer than ten per cent of high school students enroll in courses in chemistry. A recent survey made by a committee of the Chemistry Teachers' Club in New York shows that the enrollment is increasing slightly in New York City schools. For the nation as a whole, however, little change in the percentage of enrollment has apparently taken place for several years.

Many teachers of chemistry are keenly aware of this situation. More progressive teachers have tried introducing courses in practical chemistry. Efforts have been made to remove the subject from the college preparatory strait-jacket and make it meet the needs of modern life.

Some have sought to meet the difficulties by substituting demonstrations by teachers for pupil experiments, and this tendency has been accelerated somewhat by evidence that written examinations could be passed by pupils who had watched demonstrations with success comparable to that of those who had performed the usual experiments.

Many writers continue to urge emphasis upon the teaching of "scientific method." But these efforts have only been partly successful. Again and again we are forced to realize that acquiring the "scientific method" in a laboratory situation is one thing—applying it to problems outside of the classroom is another thing.

One of the tenets of educational psychology is that high school pupils learn more readily when the material is meaningful to them. Accordingly, it seemed desirable to make an effort to find out what elements of chemistry *are* interesting to high school students, by their own admission.

It was decided that information as to what high school students think of chemistry, and why they hold their opinions, might be deduced from short essays they might write on the subject, "Why I like or dislike chemistry."

Signatures were not required and no pupil was forced to write the essay. In order to lessen the personal influence of a single teacher, another teacher in the same school, and two teachers in a neighboring school, were induced to cooperate.

An examination of 256 of these essays revealed certain points on which more definite information seemed desirable, and so a questionnaire was circulated among the pupils in the first school, the Erasmus Hall High School in the city of New York. Before discussing the findings of the questionnaire approach, an analysis of the essays may be offered.

TABLE I

OPINIONS FAVORABLE TO CHEMISTRY AS REVEALED IN 256 ESSAYS ON "WHY I LIKE OR DISLIKE CHEMISTRY"

1.	Enjoyed chemistry in general	224
2.	Enjoyed laboratory work	109
3.	Found it useful	84
4.	Brought about a better understanding of nature	65
5.	Gave new experiences	58
6.	Helped to organize thinking	8
7.	Stimulated thought	7
8.	Has the appeal of mystery	7
9.	Sketching apparatus interesting	7
10.	Electron theory was intriguing	7
11.	Satisfied curiosity	6
12.	Found equations interesting	6

TABLE II

OPINIONS UNFAVORABLE TO CHEMISTRY AS REVEALED IN 256 ESSAYS ON "WHY I LIKE OR DISLIKE CHEMISTRY"

1.	Did not like it	28
2.	Did not like valence	26
3.	Did not like equations	14
4.	Did not like problems	9
5.	No practical use for it	8
6.	Too hard	7
7.	Could not understand it	7
8.	Did not like tests	6
9.	Indifferent	4

It will be observed that 224 of the 256 essay writers said that they enjoyed chemistry. Since they were under no obligation to write the essay and under no obligation to sign their names to it, we may assume that the general reaction of those enrolled in the chemistry courses was favorable.

More specific questions were asked of the respondents in the questionnaire, circulated among Erasmus Hall High School pupils in chemistry. These questions, with the responses, are given in Table III.

CONCLUSIONS, OR IMPLICATIONS FOR TEACHERS

Recognizing the limitations of inquiry such as this, and bearing in mind the inexperience and limited viewpoint upon which

TABLE III

QUESTIONS AND ANSWERS PERTAINING TO SPECIFIC ITEMS RELATING TO THE TEACHING OF CHEMISTRY IN ERASMUS HALL HIGH SCHOOL. BASED ON 111 REPLIES*

1. What part of the chemistry course do you find most interesting?	
a. Laboratory experiments	65
b. Atmosphere	8
c. Organic chemistry	7
d. Study of synthetic products	6
e. Preparation of oxygen and hydrogen	5
f. Acids and bases	5
2. What part do you find most useful?	
a. Manipulation	15
b. Applications	10
c. Organic chemistry	9
d. All parts of the subject	8
e. Fuels	6
f. Oxygen	5
3. What part do you find least interesting?	
a. Valence	27
b. Problems	26
c. Equations	11
d. Theories	10
e. Notebooks	6
4. Would you advise dropping equation writing?	
Yes	19
No	91
5. Would you advise dropping valence and formula writing?	
Yes	34
No	77
6. Would you advise dropping working of problems?	
Yes	37
No	74
7. Would you extend or shorten the time spent studying scientific methods?	
Extend	61
Shorten	21
Leave as it is	16
8. Would you increase or decrease the number of experiments performed by pupils?	
Increase	97
Decrease	4
Leave as it is	4
9. Would you include more detailed study of applications of chemistry?	
Yes	63
No	33
Remain the same	3

* As a rule only items reported by five or more respondents are included.

10. Below is a list of topics not now studied. Indicate those you would like to study. Mark your first choice one, etc.

Choice	1	2	3	4	5	6
a. Fertilizer	1	4	4	13	19	24
b. Cosmetics	15	12	15	10	16	16
c. Patent medicines	28	29	14	13	6	0
d. Foods	17	25	23	12	2	1
e. Photography	34	18	21	11	8	2
f. Analyses	10	14	9	13	14	14

the student must base his judgment, certain observations may be made as to the meaning of these findings.

1. *Individual laboratory work for pupils should be extended.*

Evidently the pupil wants more, rather than less laboratory work. But it is also evident that the work should be stripped of banal and stereotyped emphasis on formalities and directed to the phase which has to do with "things happening."

Individual laboratory work is usually defended on the grounds that it teaches the scientific method or laboratory method. We could do away with this argument and let the case rest on the fact that laboratory work is a motivating influence. It is worth while for this reason alone.

2. *The practical appeal of chemistry should be utilized.*

Most pupils want more study of the applications. Pupils really want to know the chemistry of articles in daily use in their homes.

3. *The course in chemistry should tie up with pupils' life experiences.*

Chemistry should be taught in such a manner as to satisfy curiosity about natural phenomena. This is more likely to prove effective than any effort to teach a formal array of facts and theories.

4. *The aim of teaching the "scientific method" may be partly realized.*

A few pupils seem to be interested in this phase of chemistry. For them, instruction in the methods of science may prove rewarding. Efforts to teach the scientific method need not be abandoned, but should be approached realistically and without exaggerated notions about what can be accomplished.

5. *Certain topics and procedures in chemistry may be made optional.*

The attitude of pupils toward the study of valence, formula writing, equation writing, and problems, was surprising. It should prove better to make this part of the chemistry course

optional. Except for pupils going to college, few will have need of this knowledge.

Those who like this type of chemistry and those who wish to use chemical shorthand or to be able to calculate the quantities of reagents needed in an experiment will learn these things without being forced to do so. Those who prefer to spend their time studying practical applications or striving to understand natural phenomena should be encouraged to work hard at these tasks.

6. *Chemistry courses may be enriched by studying pupils' local needs.*

Question 10 of the questionnaire indicates a method which may be used to determine how to enrich the chemistry course according to the local needs of pupils. In these studies fertilizer was rated least desirable as a topic for study. In rural schools its rating probably would be higher.

Aside from the conclusion that laboratory work does have actual and potential appeal to students who elect chemistry courses, at least one other generalization seems to grow out of the study. It is that students are not necessarily asking for "something easy." They merely desire that what they are expected to do shall have meaning.

ALUMINUM USE

Germany leads the world in per capita consumption of aluminum, figures gathered by the Frankfurter Metallgesellschaft reveal. Per capita consumption of the metal ranges about 1.95 kilograms (4.28 pounds) as compared with 1.18 kilos (2.6 pounds) in the United States and 1.05 kilos (2.31 pounds) in Great Britain.

Part of the heavy German advantage in the use of the light metal comes from the fact that greater use of aluminum is made in the electrical industry than elsewhere, where copper is used. The United States, Great Britain and Sweden, all of which command ample sources of copper, are much heavier users of the soft, red metal than is the Nazi Reich.

RATS CARRY VIRUS

Rats are blamed for the spread of hoof and mouth disease in livestock, by Dr. Heinrich Rosenhaupt, public health director of Frankfurt, Germany.

The virus of this serious cattle disease, which also attacks human beings, is known to live in the earth and manure of barnyards and stables. Dr. Rosenhaupt's idea is that the rats, themselves apparently immune, carry the virus in muck that adheres to their feet. They are known to migrate, often in large hordes and for long distances, which in the physician's opinion makes their activities all the more dangerous.

HEAT AND KINETIC THEORY FROM THE STANDPOINT OF SCIENTIFIC METHOD

By Winston Gottschalk

Saint Mark's School, Southborough, Massachusetts

Ask almost any science teacher what he considers the most important part of his course, and he will answer that the scientific method is the core of his subject. With this thought in mind I have been at a loss to understand why we physics teachers miss what seems to me to be our best opportunity to develop an example of this method. It means the introduction of little, if any, material that is not now taught and is relatively easy to understand. A unified and logical treatment of heat and kinetic theory can serve as a fine example of the processes of science.

I would suggest that the facts of heat be taught first, simply from the experimental viewpoint. We know that a gas exerts pressure and experimentally we usually deduce that the pressure is inversely proportional to the volume if the temperature is constant. I think it worth while to try in the laboratory to give the students the feeling that this statement is true only to the degree of accuracy to which they do the experiment. I find that the biggest obstacle that most secondary school students have in really appreciating the way a physicist works lies in their assumption that everything is accurate. Anyway the gas laws can be worked out from the empirical side. The principles of heat exchanges are most easily taught purely from the practical side. Most students can see that we can measure heat without any idea as to what it really is. In fact, what is more natural than to measure the unit of heat precisely as it is defined?

The last step in this treatment of heat from the practical side is of course the idea of the mechanical equivalent of heat. I feel that this part of the subject should receive more careful handling than is generally given to it. The fact that mechanical work goes into heat should be illustrated as profusely as possible and not left in the mind as simply paddle wheels churning up some water. If any teacher will look up some of the literature, he will find that this was a big step for science. Incidentally the lives of men like Joule and Rumford are interesting and can be used to make the class periods interesting. Epstein's *Textbook on Thermodynamics* has a very good chapter on the principle of the conservation of energy, where the subject is considered historically and philosophically.

Now, from my standpoint, is the time to enter into the field of kinetic theory. I feel very strongly that it is a mistake to introduce the concept of molecules until this point. It is not logical, and I do not feel that it is good pedagogy. Furthermore, the idea of molecules should enter as an assumption and not as a fact. No honest physicist would state that he *knew* that there are such things as molecules. Yet there are physics teachers who like to start the course teaching about molecules.

After the usual work on diffusion to bring out the plausibility of the assumption of molecules in rapid motion, one can show that after Joule's work it was natural to attempt to explain heat as the energy of these molecules. Incidentally, historically this was somewhat on account of the fact that mechanics was the only well developed field of physics at that time. Likewise, with our classes at this time their knowledge of physics is largely mechanics. What is better than to show the students that what they have learned can be applied right here?

If we make the assumptions usually made in kinetic theory, i.e., existence of molecules, lack of forces between them, elasticity, and motion, we can go right to work to explain gas pressure. The idea is quite a normal one and the well known proof of $pv=RT$ by assuming three streams of molecules is by no means beyond a high school class. As a matter of fact it can be a welcome review of fundamentals. And it leads to a correct interpretation of absolute temperature as the average kinetic energy per molecule. This, it seems to me, is valuable. Friends of mine who read College Board papers tell me that this point is one of the most often missed on the papers they see. Students seem to have the impressions that a rise in temperature causes, and therefore is distinct from, a change in the velocity of the molecules. One well known physics text makes a number of loose statements about this point. I remember in particular a statement that heating a gas causes the molecules to speed up and hence the speed of the molecules is a measure of the temperature of a gas. This is true in a way, but the average student will read into the statement that the molecules of gases at the same temperature will have the same speed (average), and would be justified in this statement from what he has been taught.

The introduction of the idea of potential energy leads to a clear treatment of latent heats. I do not feel it is a bad idea to introduce the subject of a more generalized kinetic theory.

Drop the assumption of no forces between molecules and we can get qualitative explanations of the three states of matter, latent heats, evaporation, specific heats, surface tensions, and even thermal expansion. There are some simple non-mathematical treatments of kinetic theory available which can be put in the library for our better students to read. The subject itself is interesting, and I have found that it can serve the student as it serves the physicist. By this I mean that he will have in one unified theory all his knowledge of heat.

Most of what I have said is familiar to any physics teacher. To summarize I would say that my main point is that the important thing is the order in which heat unit is taught. It can be a heterogeneous affair or a genuine example of the growth of a scientific theory. The reader has probably not missed my point that we teachers should not be guilty of getting our students to "believe in" molecules, but should put them in simply as a convenient concept. A perusal of most of the high school chemistry books will show that as far as the books are concerned molecules are introduced properly. The texts I am familiar with obtain the ideas of molecule simply to explain the laws of definite composition, multiple proportions, and conservation of matter. Why can't we physicists be equally honest with our pupils?

VITALIZING GEOMETRY BY THE USE OF PICTURES

By Donovan A. Johnson
Sheboygan High School, Sheboygan, Wisconsin

Attractive and unusual pictures furnish an effective means of teaching visually mathematical principles so that pupils will recognize, think and use mathematics in their everyday life. The enormous popularity of the new picture magazines shows the widespread appeal of pictorial material.

Attractive pictures with mathematical problems, quotations and captions on the bulletin board have helped greatly to add life and interest in my geometry classes.

My geometry classes have been divided into committees of two or three. These have selected their topic from a suggested list. The project consisted in finding suitable pictures, problems and quotations to illustrate the principles or applications of

their topic. Each display had a suitable background, which added to its attractiveness, and a symmetrical arrangement of the pictures. The pupils enjoyed making their display and, as one of the students put it, "never realized before that geometry is used so much."

The following is an abbreviated list of topics which can be advantageously illustrated by pictures.

1. Geometry in art
2. Mathematics in nature
3. The use of triangles
4. Optical illusions
5. Geometric church windows
6. Making multiplication easy
7. Circles
8. Geometry in the home
9. Bridge builders are mathematicians
10. Parallel lines
11. Symmetry
12. Mathematics in photography
13. Vocations requiring a background of mathematics
14. Objectives of mathematics

In addition to the teaching values, these displays make the classroom more attractive and provide an atmosphere that is appropriate to the work that is being studied. The displays can also be used as mathematical exhibits in the school to convince the student body that modern scientific and social knowledge is clamoring for more mathematics. The great interest in "quiz" radio programs and the success of recent popular mathematics books testify to the lively curiosity and interest of the general public in mathematics when it is presented in a simple way.

However, it is often difficult to get suitable pictures to illustrate certain principles and uses of mathematics. Picture magazines, advertisements and various publications for photographers have some fine material that can be used to relate mathematics to community activities and in that way emphasize the importance of mathematics as a foundation for the understanding of the social and physical environment.

David W. Russell of National College of Education at Evanston, Illinois has solved this difficulty of obtaining illustrations by having his pupils take snapshots of related material.[1] That is a good method but one that cannot be used to a great extent in smaller communities.

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[1] Russell, David W., "Introducing Mathematical Concepts in the Junior High School," SCHOOL SCIENCE AND MATHEMATICS, XXXVIII, No. 1, pp. 6–19, January 1938.

Many pupils do not appreciate the value of mathematics because they are told continually by outsiders that mathematics is of no practical value. However, when a pupil sees how mathematics will measure some unknown distance or how the business man uses it in his daily work, then mathematics loses its abstraction and takes on meaning.

Visual material then will enable the student to understand the importance of mathematics in the activities of the world. This means that the student will see mathematics as a subject that is alive. And if mathematics can be made alive, useful and comprehensible, it is on the way in instead of on the way out.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

LATE SOLUTIONS

1560. *Hazel C. Jones, Danville, Illinois.*

1562. *Proposed by Joseph Bena, Leetsdale, Pa.*

A sphere with diameter of one foot is rolled into the corner of a room so as to be tangent to the floor and two walls.

(a) Find the diameter of a larger sphere which is tangent to the given sphere, the floor and two walls.

(b) Find the diameter of the smaller (inner) sphere tangent as in (a).

Solution by S. E. Field, Junior College, Ironwood, Michigan.

Let O be the corner of the room, C the center of the given sphere, C_1 and

C_2 the centers of the outer and inner spheres, and R, R_1, and R_2 the radii of the three spheres.

$$OC = R\sqrt{3}$$

$$OC_1 = R_1\sqrt{3} = R\sqrt{3} + R + R_1$$

and

$$OC_2 = R_2\sqrt{3} = R\sqrt{3} - R - R_2.$$

From these we obtain

$$R_1 = (2+\sqrt{3})R$$

and

$$R_2 = (2-\sqrt{3})R_1.$$

Since $R = 1$ foot, $R_1 = 3.732$ feet and $R_2 = 0.268$ foot.

Solutions were also offered by W. R. Warne, Minneapolis, Hugo Brandt, Chicago, Arthur Danzl, Collegeville, Minn., D. L. MacKay, New York City, W. R. Smith, Chicago, and Charles W. Trigg, Los Angeles.

1563. *Proposed by W. R. Warne, Minneapolis.*

A square tract of land has as many acreas as there are boards in the fence enclosing it. Each board is 11 feet long and the fence is four boards high. How many acres in the square?

First Solution.

By Lester Dawson, University of Alaska, College Alaska.

Let

$$x = \text{number of acres in tract of land.}$$

Then

$$160x = \text{number of square rods in area.}$$

$$4\sqrt{10x} = \text{length of each side in rods.}$$

$$16\sqrt{10x} = \text{perimeter in rods.}$$

Since the number of boards in perimeter = number of acres, and since one rod has 6 boards, we have:

$$x = 6 \cdot 16\sqrt{10x}$$

whence, by squaring,

$$x^2 = 92160x.$$

So that

$$x = 92160 \text{ and } 0.$$

Second Solution.

By Mrs. Edith M. Warne, Minneapolis.

Since each panel is 11 feet long, in one rod of fence there is $\frac{3}{2}$ of a panel. If r is the number of rods in one side of the tract there are $3r/2$ panels on one side. Hence the total number of boards in the perimeter is $24r$

$$\text{The number of acres in the field} = \frac{r \times r}{160}\cdot$$

Hence

$$\frac{r \times r}{160} = 24r$$

from which

$$r \times r = 3840r$$

and

$$r = 3840.$$

The number of acres is then

$$\frac{3840 \times 3840}{160} = 92160.$$

Solutions were also offered by Hugo Brandt, Chicago, W. R. Smith, Chicago, Dean Branstetter, Vandalia, Mo., D. L. MacKay, New York City, M. Kirk, West Chester, Pa., Charles W. Trigg, Los Angeles, Fred Marer, Los Angeles, Miss Ione Edwards, Minneapolis, Minn., Grace E. Hicks, Romulus, N. Y., Hazel C. Jones, Danville, Illinois, S. F. Field, Ironwood, Mich., and the proposer.

1564. *Proposed by Charles W. Trigg, Los Angeles.*

From three stations on a line passing through the foot of a tower the angles of elevation of the top of the tower are taken. At the middle station the angle is the complement of the angle at the station 40 feet farther from the tower, which angle is one-half the angle from the station 20 feet closer to the tower than the middle station. How high is the tower?

Solution by Aaron Buchman, Buffalo, New York.

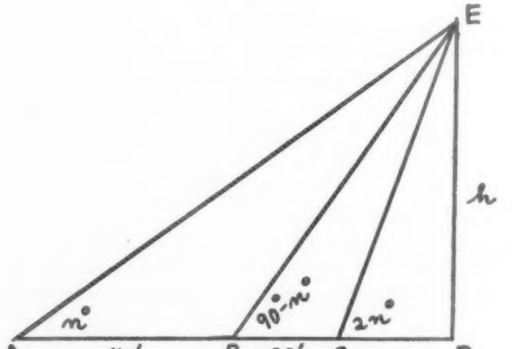
$$\tan n^\circ = \tan EAD = \frac{h}{x+60} \tag{1}$$

$$\tan n^\circ = \tan BED = \frac{x+20}{h} \cdot \tag{2}$$

From (1) and (2)

$$\frac{h}{x+60} = \frac{x+20}{h} \quad \text{or}$$

$$h^2 = (x+20)(x+60) \tag{3}$$



It is easily shown that angle $AEC = n^\circ$, so that triangle AEC is isosceles and

$$EC = AC = 60 \text{ feet.}$$

Then

$$x^2+h^2=60^2 \quad \text{or}$$
$$h^2=3600-x^2. \tag{4}$$

Using (4) in (3)

$$3600-x^2=(x+20)(x+60).$$

Solving for the positive value of x

$$x=20. \tag{5}$$

Substituting (5) in (3)

$$h=40\sqrt{2} \text{ feet.}$$

Solutions were also offered by Hugo Brandt, Chicago, D. L. MacKay, New York, Fred Marer, Los Angeles, Calif., W. R. Smith, Chicago, S. E. Field, Junior College, Ironwood, Michigan, D. F. Wallace, New York, Arthur Danzl, Collegeville, Minn., W. R. Warne, Minneapolis, Minn., and the proposer.

1565. *Proposed by Cecil B. Read, University of Wichita, Kansas.*

Show that if x lies between zero and π, cot $x/4-\cot x$ is greater than 2.

Solution by the Proposer.

$$\cot x/4-\cot x=\frac{\sin 3x/4}{\sin x/4 \sin x}=\frac{3-4\sin^2 x/4}{\sin x}$$
$$=\frac{1+2\cos \frac{1}{2}x}{\sin x}=\csc x+\csc \tfrac{1}{2}x.$$

The cosecant is never less than unity for the angle between 0 and π neither can both be unity simultaneously, hence the statement is proved. (Note: This problem is in Hobson's *Plane Trigonometry.*)

Solutions were also offered by Hugo Brandt, Chicago, M. Kirk, West Chester, Pa., Charles W. Trigg, Los Angeles City College, Fred Marer, Los Angeles.

1566. *Proposed by Walter R. Warne, Minneapolis.*

Solve for x,

$$\sum \frac{b+c}{x-a}=3.$$

Solution by D. L. MacKay, New York City

$$\frac{b+c}{x-a}+\frac{a+c}{x-b}+\frac{a+b}{x-c}=3, \tag{1}$$

which may be written

$$\frac{b+c}{x-a}-1+\frac{a+c}{x-b}-1+\frac{a+b}{x-c}-1=0, \tag{2}$$

from which it follows that,

$$(a+b+c-x)\left(\frac{1}{x-a}+\frac{1}{x-b}+\frac{1}{x-c}\right)=0. \tag{3}$$

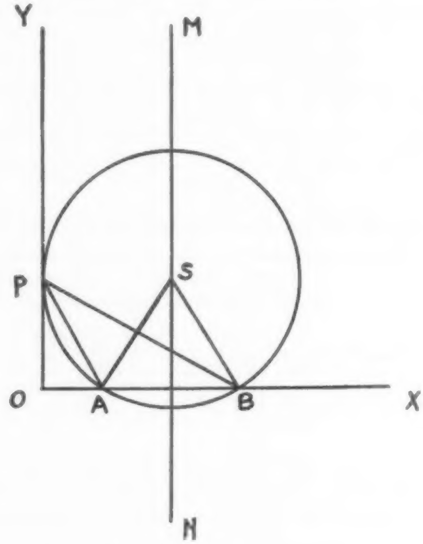
Setting each factor equal to zero, by simple algebra, one obtains

$$x=a+b+c \quad \text{and} \quad \frac{a\pm\sqrt{\sum a^2-3\sum ab}}{3}. \tag{4}$$

A solution was also offered by the proposer.

1567. *Proposed by Aaron Buchman, Buffalo, New York.*

If OX and OY are two perpendicular rays; A and B, two fixed points on OX; P, a variable point on OY; without the use of calculus, find the position of P which makes $\angle APB$ a maximum.



Solution by Proposer.

Let S be the center of the circle through A, B, and P. The locus of the center S, as P varies, is MN, the perpendicular bisector of AB. $MN \| OY$.

Now as the radius of circle S decreases, central $\angle ASB$ increases, so that the number of degrees in the minor arc AB increases, and therefore inscribed $\angle APB$ increases.

But the smallest circle, which has its center on MN and has a point in common with OY, is one tangent to OY. Therefore the position of P which makes circle S tangent to OY makes $\angle APB$ a maximum.

Using the relation between the tangent and a secant to a circle, $\overline{OP}^2=\overline{OA}\cdot\overline{OB}$, and $\overline{OP}$ can be constructed, locating the required point P.

Solutions were also offered by Charles W. Trigg, Los Angeles, D. F. Wallace, New York, Hugo Brandt, Chicago, Ill., W. R. Smith, Chicago, M. Kirk, West Chester, Pa., D. L. MacKay, New York, Fred Marer, Los Angeles, W. R. Warne, Minneapolis, Minn.

HIGH SCHOOL HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems

submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

1563. *Jim Chapman and Jack Russell, Perry, Iowa.*

PROBLEMS FOR SOLUTION

1580. *Proposed by Hugo Brandt.*

In a triangle ABC, produce AB to L, BC to M, CA to N so that $BL=AB$, $CM=BC$, $AN=CA$. If ABC has an area of F, prove that LMN has an area of $7F$.

1581. *Proposed by Norman Anning, University of Michigan.*

Reduce to lowest terms $\dfrac{1234567.5}{3456789}$.

1582. *Proposed by Aaron Buchman, Buffalo, N. Y.*

Two straight roads intersect at right angles. A sign which is r feet long is placed along one road at a distance of m feet from the intersection. Without the use of calculus, find the point on the other road at which the sign subtends the greatest angle, that is, the best point from which to view the sign.

1583. *Proposed by Norman Greenspan, Brooklyn, N. Y.*

Find the number of terms in the expansion $(a+b+c+\cdots \text{ to } n \text{ terms})^p$ expressed as a function of p and N.

1584. *Proposed by Clarence J. Leonard, Detroit.*

A circle has a radius of one inch. Find the radius of a second circle having its center on the circumference of the first circle and cutting off one half its area.

1585. *Proposed by Cecil B. Read, Wichita, Kansas.*

Find, by plane geometry, a point in a given straight line at which two given points on the same side of the line subtend the greatest angle.

SCIENCE QUESTIONS

Conducted by Franklin T. Jones

(Send all communications to Franklin T. Jones, 10109 Wilbur Avenue, S. E. Cleveland, Ohio.)

Readers are invited to co-operate by proposing questions for discussion or problems for solution.

Examination papers, tests, and interesting scientific happenings are very much desired. Please enclose material in an envelope and mail to Franklin T. Jones, 10109 Wilbur Ave., Cleveland, Ohio. Thanks!

Your classes and yourself are invited to join the GQRA (Guild Question Raisers and Answerers). More than 254 others have already been admitted to membership by answering a question or proposing one that is published.

BECOME MEMBERS OF THE *GQRA*

DO YOU KNOW THE ANSWERS?

Contributors are requested to propose short snappy questions for this section of SCIENCE QUESTIONS.

(*Continued from October and November, 1938*)

16. Are we walking "feet up"? They say the eye "inverts the image." If we see an inverted image "right-side up," are we "wrong end up"?
17. Can you see more or less of the road behind you with a convex rear vision mirror than with a plane mirror?
18. Why are modern windshields on autos inclined? How much and Why?
19. What was the "Great Meteor"?
20. Propose a question that 100 readers of SCHOOL SCIENCE AND MATHEMATICS will answer.

ANSWERS

To "Do you Know the Answers?" for October 1938

1. **(833)** Cows sleep on their *right* side and lay their heads over against their *left* side. Stanchions are designed so as not to interfere.
2. **(827)** No matter how careful you are your tennis racket will be "off balance" with respect to its *long* axis when you throw it up (In technical words there will be a "couple" making it rotate about the *short* axis.) so it is bound to rotate so that you can not catch it the same side up as you threw it.
3. **(830)** See answer by K. P. Kidd in June, 1938.
4. **(832)** Write to "The Talon," Geneva High School, Geneva, Ohio.
5. **(818)** See another answer in this number of SCIENCE QUESTIONS.
6. **(840)** An American inch is defined by Act of Congress as 25.40005 millimeters. An English inch is 25.39996 millimeters.
7. **(838)** Ice that sinks has been made in the high pressure laboratory at Harvard University "by putting a squeeze of 30,000 pounds to the square inch on water."
8. **(839)** The deer botfly is said to be the fastest living creature.
9. Where is that examination paper you were going to send the *Editor?* He doesn't know. He has not seen it yet.
10. Get into the GQRA by contributing to SCIENCE QUESTIONS. Two hundred and fifty-four are already members.

THE MAGDEBURG HEMISPHERES AGAIN

819. How many horses were used to separate the Magdeburg hemispheres? (*Proposed by James A Lemon GQRA No.* 142, *Comments by F. H. Wade, GQRA No.* 205, *May, 1938.*)

Answer by Adrian Struyk (GQRA No. 75), Paterson, N. J.

"In the volume *Source Book in Physics*, edited by W. F. Magie, there is an extract from a work by Otto von Guericke, describing various attempts to produce a vacuum. Following the extract is an editorial comment on the remainder of the work. It is there stated, in connection with the Magdeburg hemispheres, that "sixteen horses pulling in teams of eight against each other could not separate them." (Pp. 80–84 of the *Source Book.*)

Further comment by F. H. Wade (GQRA No. 205), Chicago, Ill.

In my comment on the Magdeburg Hemispheres (p. 819, May issue of the Journal), I wonder how many will notice the strange arithmetic stating that $4\times 2360 = 10{,}446$.

How this blunder happened I assure you that I have not the wildest idea. I am much better in long division, and hereafter will confine myself to problems involving this operation.

I will, however, still hold to the statement that 8 horses on one end and 8 horses on the other end make 8 horses altogether, and that a 30″ hemisphere as shown in the picture is just about right.

WORK ON A MOVING STAIRWAY

820. *Proposed by Dr. John C. Packard, Brookline High School, Brookline, Mass. (GQRA No. 1.)*

"Does it require more or less work on the part of the hoisting engine to carry a man up a moving stairway when he is walking up the stairs while the heads are moving than when he stands still?"

Problem as re-proposed and answered

Does the motor of an escalator do more work or less if the man runs up the stairs instead of standing still?

Solution by Edward R. Cooper (Elected to the GQRA No. 254), Brookline High School, Brookline, Mass.

The work done by the motor is the force exerted multiplied by the distance this force moves. If the man stands still the work done is the product of the man's weight and the height his weight is raised. Now if he runs up the stairs at a *steady* speed he pushes down with no more than his own weight (if we neglect the small force to overcome air friction) so the motor works no harder; furthermore, since the man climbs part way, the motor exerts its force through a shorter distance. Hence the work done by the motor is *less* if the man runs up at a steady speed than if he stands still.

Now suppose the man to be undergoing uniform acceleration. Then the force he applies to the stairs will be greater, for it will be the sum of his weight plus the accelerating force, or

$$F=W+Ma$$

where W is his weight
M is his mass
a is his accel.

In this case the work done on the man by the escalator is this force (F) multiplied by the distance he is elevated; this distance is the distance between floors (D) minus the distance (d) which the man climbs. Thus the work done by the motor is

$$FH=(W+Ma)(D-d), \qquad \text{where} \qquad H=D-d.$$

But

$$d=\text{av. velocity}\times\text{ time}=\frac{at^2}{2}.$$

And the work done is thus:

$$F\times H=(W+Ma)\left(D-\frac{at^2}{2}\right).$$

Now, the time may be obtained from the relation

$$\text{distance}=\text{av. velocity}\times\text{time}, D=\left(v_t+\frac{at}{2}\right)\times t,$$

where v_t is rate of escalator.

This gives the quadratic equation

$$\frac{at^2}{2}+v_it-D=0.$$

Which may be solved by the quadratic formula, giving

$$t=\frac{-v_i\pm\sqrt{v_i^2+2Da}}{a}\cdot$$

This is rather an awkward expression to substitute in our equation for work done by the escalator, so I suggest that we leave our general solution at this point and consider the effect in a particular case of varying the man's acceleration, holding all the other factors constant. Let us take his weight as 150 lb $=W$, the floors as 20 feet apart $=D$, v_i as 5 ft/sec, and let us take accelerations of ½, 1, 2, 4, 6, 8 ft/sec² respectively. The results appear below in tabular form:

acceleration (a)	time (t)	Work done by escalator ($F\times H$)
½ ft/sec²	3.4 sec	2600 ft. lb.
1	3.1	2350 "
2	2.6	2100 "
4	2.14	1820 "
6	1.88	1680 "
8	1.68	1620 "

Evidently, as the acceleration increases, the work done by the escalator becomes less.

Let us now consider the work done by the man. If he stands still on the escalator he does no work. If he runs at a uniform rate (which he attained before getting on the escalator) he does work given by

$$\text{Work}=\text{Weight}\times\text{velocity}\times\text{time}=Wv_2t.$$

The time can be obtained from

$$t=\frac{D}{v_1+v_2}\cdot$$

Thus using the data above, if the velocity of the man is 3 ft/sec, the time is

$$t=\frac{20\text{ ft.}}{5\text{ ft./sec.}+3\text{ ft./sec.}}=\frac{20\text{ ft.}}{8\text{ ft./sec.}}=2.5\text{ seconds.}$$

And the work done by the man is

$$\text{Work}=150\text{ lb.}\times3\text{ ft./sec.}\times2.5=1125\text{ ft./lb.}$$

The work done by the escalator is given by

$$\text{Work}=W\times(D-v_2t)=150\text{ lb.}\times(20\text{ ft.}-3\text{ ft./sec.}\times2.5\text{ sec.})=1875\text{ ft. lb.}$$

which added to that work done by the man gives 3000 ft. lb., the work which would have been done by the escalator if he had been standing still.

In the case of the man who is uniformly accelerating his motion as he moves up the steps, the work done by the man is given by

$$\text{Work}=(W+Ma)\times\frac{at^2}{2}\cdot$$

Using this formula and the data assumed above the results given in the table below were obtained. In the fourth column the work done by the man has been added to that done by the escalator. It is interesting to note that in this case more work is done altogether than if the man had remained standing still on the stairs. This is due to the fact that he reaches the upper floor with his energy increased not only by the added potential energy, but also by the kinetic energy of his accelerated motion.

acceleration	work by man	work by motor	sum of work by man and motor
$\frac{1}{2}$ ft/sec^2	406 ft. lb.	2600 ft. lb.	3006 ft. lb.
1	745	2350	3095
2	1078	2100	3178
4	1550	1820	3370
6	1890	1680	3570
8	2100	1620	3720 ft. lb.

From the above discussion it thus appears that from the standpoint of the motor any motion of the man up the stairs reduces the work that the escalator motor must do in elevating him.

CURRENT IN INDUCTION COIL—PULSATING OR ALTERNATING—ANSWER

845. *Proposed by John Kilpatrick (GQRA No. 250), and Basil C. Barbe, (GQRA No. 218), Stephen F. Austin College, Nacogdoches, Texas.*

"In an induction coil whose primary is driven by a direct-current source (being interrupted, of course), is the voltage developed across the secondary alternating or pulsating current?"

Answer by C. S. Greenwood (GQRA No. 135), Sheffield, Pa.

"I wish to submit my answer to Science Question No. 845, on the type of current in the secondary coil of an induction coil, published in the October, 1938, issue of School Science and Mathematics.

It seems to me that the current in the secondary circuit of an induction coil *could be* an alternating current (although with the e.m.f. in one direction so enormously greater than that in the other direction that the latter phase is negligible), but that it is ordinarily an interrupted direct current. My reasoning is as follows:

When the primary circuit is closed, the current through the primary coil increases from zero to its maximum, causing a spreading out of lines of force which produces a current in the secondary coil in the opposite direction from that of the primary coil—according to Lenz' Law. The breaking of the circuit does just the opposite, that is, it causes a contraction of the lines of force produced by the primary coil and thus sets up in the secondary coil a current in the same direction as that of the primary coil.

But the breaking of the circuit is much more rapid than the making of the circuit, especially when a condenser is used in the primary circuit, and the speed of change of the primary current determines the speed with which the lines of force spread or contract and therefore the magnitude of the e.m.f. of the secondary current. Since the speed of the break is much greater than the speed of the make, the e.m.f. produced by the break is much greater than that produced by the make. In fact, the e.m.f. produced by breaking the primary current, i.e., the secondary e.m.f. which produces the spark, may be 10,000 times as great as the secondary e.m.f. in the opposite direction—that which is produced by the closing of the primary

circuit. (Millikan, Gale, and Edwards—*A First Course in Physics for Colleges*, p. 434.) Therefore, when the terminals of the secondary circuit (the sparking points) are close enough to produce a spark on the breaking of the primary circuit, they would have to be moved much closer together to allow the other phase of the induced current to jump across the gap. Such a distance would be exceedingly small. When the distance between the points is too large for the secondary current to jump the gap, then, of course, the circuit is incomplete and therefore there is no secondary current."

Also answered by Glen W. Warner (GQRA No. 18), Chicago, Ill.

"The secondary voltage of an induction coil is always alternating, but because the decay of the primary current takes place so much more rapidly than the growth of the current if the coil has a good condenser and spark gap, the secondary voltage is much higher on the break than on the make. This makes it possible to set the discharge gap too great for a discharge to pass on the make but still allow the higher voltage on the break to discharge across the gap. Such a gap is a sort of valve and gives a pulsating direct current in the secondary circuit."

ZOOLOGY FOR DRIVERS

848. "A car is like a cat" (Cleveland News)

"At 25 miles an hour it may scratch you up but it isn't likely to kill you.

"At 50 miles an hour it is *not twice* but *four* times as powerful.

"At 75 miles an hour it is not *three* times but *nine* times as powerful as at 25. Nine times as hard to *stop*—nine times as hard to *turn*—nine times as *deadly*."

(*A little discussion, Please*—The Editor.)

THINK WHEN YOU BLOW YOUR HORN

849. *From "Fun with Facts" by Colin Simkin*

A motorist traveling 40 m.p.h. blew his horn to warn a pedestrian 60 feet ahead. Sound travels 1100 feet per sec. How much time would the pedestrian have to step aside?

SUGGEST QUESTIONS

Please suggest questions to be inserted under

"DO YOU KNOW THE ANSWERS?"

GQRA CONTRIBUTORS—YEAR BY YEAR

1933—October to December, Nos. 1 to 10;
1934—January to December, Nos. 11 to 47;
1935—January to December, Nos. 48 to 113;
1936—January to December, Nos. 114 to 154;
1937—January to December, Nos. 155 to 201;
1938—January to December Nos. 201 to 254.

BOOKS RECEIVED

A Course of Study in Chemical Principles, by Arthur A. Noyes, Late Professor of Chemistry, California Institute of Technology, and Miles S. Sherrill, Professor of Physical Chemistry, Massachusetts Institute of Technology. Second Edition, Rewritten. Cloth. Pages xxv+554. 14×21.5 cm. 1938. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $5.00.

An Analysis of Proofs and Solutions of Exercises Used in Plane Geometry Tests, by Hale Pickett, Teachers College, Columbia University. Cloth. 120 pages. 15×23 cm. 1938. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $1.60.

Elliptic and Hyperelliptic Integrals and Allied Theory, by The Late W. R. Westropp Roberts, Vice-Provost of Trinity College, Dublin. Cloth. Pages viii+311. 13.5×22 cm. 1938. Cambridge University Press, London or The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.75.

Biology, by Thurman J. Moon, Head of the Science Department, The High School, Middletown, New York, and Paul B. Mann, First Assistant in Biologic Science and Head of Department of Biology, Evander Childs High School, New York City. Cloth. Pages x+866+c. 13×20.5 cm. 1938. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y. Price $2.00.

Our Starland, by C. C. Wylie, Associate Professor of Astronomy, University of Iowa, Iowa City, Iowa. Cloth. 378 pages. 13×19 cm. 1938. Lyons and Carnahan, 2500 Prairie Avenue, Chicago, Illinois.

Laboratory Manual to Accompany Introductory General Chemistry, by Harold G. Dietrich and Erwin B. Kelsey, Assistant Professors in Chemistry, Yale University. Revised Edition. Paper. Pages ix+218+118. 19×25.5 cm. 1938. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.90.

A Manual of Experiments to Accompany A First Course in Physics for Colleges, Revised Edition, by Robert Andrews Millikan, Director of the Norman Bridge Laboratory of Physics, California Institute of Technology; Henry Gordon Gale, Professor of Physics in the University of Chicago; and Charles William Edwards, Professor of Physics in Duke University. Paper. Pages vi+221. 19×26.5 cm. 1938. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $1.10.

The Relative Merits of Three Methods of Subtraction, by John Theodore Johnson, Teachers College, Columbia University, Contributions to Education, No. 738. Cloth. 76 pages. 14.5×23 cm. 1938. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $1.60.

Laboratory Experiments and Workbook to Accompany Black and Davis Elementary Practical Physics, by Newton Henry Black, Assistant Professor of Physics, Harvard University, and Elbert Cook Weaver, Chairman of Science Department, Bulkeley High School, Hartford, Connecticut. Paper. Pages x+290. 20×27.5 cm. 1938. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.00.

Examples in Heat, Electricity and Magnetism for Intermediate Students, by F. C. Champion, Ph.D., Lecturer in Physics, University of London, King's College. Cloth. 40 pages. 12×18.5 cm. 1938. Messrs. Blackie and Son, Limited, 50 Old Bailey, London, E.C.4.

Examples in General Physics, Light and Sound for Intermediate Students, by F. C. Champion, Ph.D., Lecturer in Physics, University of London, King's College. Cloth. 39 pages. 12×18.5 cm. 1938. Messrs. Blackie and Son, Limited, 50 Old Bailey, London, E.C.4.

General Science for Students for Seventh and Eighth Grades. Paper. Seventh Grade, 96 pages, Eighth Grade, 112 pages. 15×23 cm. 1938. Published by Cleveland Heights Board of Education, Cleveland Heights, Ohio.

Introductory Biology, by Harry L. Andrews, Nelly J. Bosma, E. C. Colin, R. Clark Gilmore, S. W. Howe, H. C. Nelson, Jesse F. Schuett, Andrew Stauffer, and John P. Wessel. Andrew Stauffer Editor. The Municipal Junior Colleges. Herzl, Wilson, Wright, Chicago, Ill. Paper. Pages vi+313. 15×22 cm. 1938.

Chemical Tables from Handbook of Chemistry and Physics, by Editor-in-Chief, Charles D. Hodgman, Associate Professor of Physics, Case School of Applied Science. Cloth. Pages xiv+1383. 11.5×18 cm. 1938. The Chemical Rubber Company, 1900 W. 112th Street, Cleveland, Ohio.

Laboratory Units in Chemistry, Manual and Study Guide for Chemistry at Work, by William McPherson and William Edwards Henderson, Both Professors of Chemistry in the Ohio State University; and George Winegar Fowler, Supervisor of Science, City Schools, Syracuse, New York and Instructor in the Methods of Teaching Science, School of Education, Syracuse University. Paper. Pages xiv+328. 16.5×23 cm. 1938. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price 80 cents.

Student's Assignment Book with Study Aids, by Ernest Choate, Principal, The Kenderton School, Philadelphia, Pennsylvania. Paper. 96 pages. 13.5×23.5 cm. 1938. The Circle Book Company, 33rd and Arch Streets, Philadelphia, Pa. Price 20 cents.

Nature and Use of the Cumulative Record, by David Segel, Senior Specialist in Test and Measurements. Bulletin 1938, No. 3. Pages v+48. 15×23 cm. United States Department of the Interior, Office of Education, Washington, D. C. For sale by the Superintendent of Documents, Washington, D. C. Price 10 cents.

The National Youth Administration, by Palmer O. Johnson, and Oswald L. Harvey with an Introduction by Doak S. Campbell. Staff Study Number 13. Prepared for the Advisory Committee on Education. Paper. Pages x+121. 15×23 cm. 1938. United States Government Printing Office, Washington, D. C. For sale by the Superintendent of Documents, Washington, D. C. Price 15 cents.

General Education Board Annual Report, 1936–1937. Paper. 148 pages. 14.5×22 cm. General Education Board, 49 West 49th Street, New York, N. Y.

Educational Temperatures, Devised by Walter Crosby Eells. Paper. 54 pages. 22×28 cm. 1938 Edition. Cooperative Study of Secondary School Standards, 744 Jackson Place, Washington, D. C.

Evaluative Criteria. 1938 Edition. Paper. 152 pages. 21×28 cm. Cooperative Study of Secondary School Standards, 744 Jackson Place, Washington, D. C.

How to Evaluate a Secondary School, A Manual to Accompany the Evaluative Criteria and Educational Temperatures of the Cooperative Study. 1938 Edition. Paper. Pages xii+115+44. 17.5×25.5 cm. Cooperative Study of Secondary School Standards, 744 Jackson Place, Washington, D. C.

Institute of International Education. Bulletin No. 1, Nineteenth Annual Report of the Director. 91 pages. 14.5×23 cm. 1938. Institute of International Education, Inc., 2 West 45th Street, New York, N. Y.

Report of the Citizens' Committee of The Chicago Park District. Paper. 32 pages. 15×23 cm. 1938. Chicago Park District, Administration Building, Burnham Park, Chicago, Ill.

The Nation's School of the Air. Joseph Ries, Director. Paper. 31 pages. 20.5×27 cm. WLW—The Nation's Station, Cincinnati, Ohio.

BOOK REVIEWS

A Textbook of General Botany for Colleges and Universities, by Richard M. Holman Late Associate Professcr of Botany, University of California at Berkeley and Wilfred W. Robbins, Professor of Botany, College of Agriculture, University of California at Davis. Cloth. Pages vii to 664. 417 diagrams and illustrations. John Wiley and Sons Inc., New York, 1938. Price $4.00.

This is the fourth edition of this excellent book. The first edition appeared in 1924. Four editions in thirteen years speaks well for the efforts of the authors to keep the book abreast of advanced scientific findings in this field. These editions have been largely rewritten, not merely revised.

The text material is divided into two parts.

I—The Structure and Physiology of Seed-bearing Plants.

II—A Survey of the Plant Kingdom with particular emphasis upon Development, Reproduction, Relationships, Evolution and Heredity.

While the book is of fair size the material in it is not necessarily superficial or extensive; it is rather complete in its discussions of the forms and processes introduced.

The historical resume of the development of the theories of evolution and heredity are good and would serve it seems to the reviewer, as an excellent reference on the subject for the high school teacher in biology who hasn't the time to go into the subject deeply. It is also felt that the authors might have made greater use as illustrations on the subject of evolution, of the great commercial vegetative products which resulted from the bud mutations.

The glossary has nearly four hundred terms. The index is rather complete. There is an appendix on reference and collateral reading arranged for sixteen subjects in this field and good taxonomy references by geographical regions of the United States.

A. G. Zander

Our Ferns, Their Haunts, Habits and Folklore, by Willard N. Clute, Editor of the *American Botanist,* Indianapolis, Indiana. Cloth, pages v to 388. 14×20 cm. Frederick A. Stokes Company, 1938. New York. Price $4.00.

This volume is intended as a guide to the Ferns of North America east of the Rocky Mountains and north of the Gulf States, there are however a few references to western and southern ferns for comparisons.

The book is divided into unnumbered sections. There are twenty-three of these sections. The first section is a narrative discussion of the physiology of the fern. The second is devoted to a discussion of the methods of reproduction in the fern. The third is a well written topic on nomenclature which in the field of the ferns is somewhat difficult. Then follow twenty sections discussing the twelve families, twenty-seven genera and thirty-four species of the ferns. This material includes a discourse on the type of habitat, geographical distribution and growing habits of each type of fern. There are two keys to the genera, a short one and an illustrated descriptive one, a key to the species, a checklist of the Ferns of North America, east of the Rockies and north of the Gulf states, a good glossary, a complete index to common names and one for scientific names.

There are seven full color, thirty-nine halftone and one hundred eighty-eight line illustrations.

The reviewer feels that wherever plant biology or nature study is taught this book will be a valuable reference.

A. G. Zander

Astronomy, A Textbook for University and College Students, by Robert H Baker, Professor of Astronomy in the University of Illinois. Third Edition. Cloth. Pages x+527. 15×23 cm. 1938. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price $3.75.

The first edition of this book published in 1930 received the hearty approval of both teachers and students. The natural approach to the subject through the observation of the positions of the bright stars, the configurations they form, and their apparent motions, leads at once to the necessity for establishing systems of celestial coordinates and to an understanding of the instruments needed for observation and measurement. Detailed study is then made of the earth and its motions, then of the moon, the sun, the planets, the stars, and so on, extending the discussion farther away in the historical order of observation and discovery. Theories are introduced as needed to explain observed phenomena, and information obtained from the physics laboratory is fully explained as occasion demands. This plan has not been altered in the two revisions made in 1933 and 1938. Each revision adds the new discoveries and shows the consequent changes in viewpoint. These improvements in the new edition are especially noticeable in the chapters on the Galactic System and Exterior Systems, but other discoveries nearer home have not been neglected. The new edition has given more attention to teaching and student aids by including a list of questions at the end of each chapter.

G. W. W.

Demonstration Experiments in Physics, by Richard Manliffe Sutton, Associate Professor of Physics at Haverford College. Cloth. Pages viii+545. 15×23 cm. 1938. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $4.50.

All teachers of physics will be delighted with this book. It describes demonstration experiments suitable for both high school and college levels for every physics unit. Almost twelve hundred lecture experiments collected from the literature and supplied by two hundred physicists representing one hundred thirty institutions is the claim of the publisher. The descriptions of these demonstrations in some cases consist of only a few lines suggesting the nature of the demonstration and leaving the details to be supplied by the instructor; but in the main the directions are complete, often including a picture or diagram. It is impossible in a brief review to give an adequate description of the book. A summary of the table of contents could list only the topics covered. But it is safe to predict that no matter how elaborate the lecture demonstration program has been in any physics department, valuable additions to the list of demonstrations may be secured from this book. No teacher of physics should be without it.

G. W. W.

Our Starland, an Easy Guide to the Study of the Heavens, by C. C. Wylie, Ph.D., Associate Professor of Astronomy, University of Iowa, Iowa City. Cloth. Pages 378. 13×19 cm. 1938. Lyons and Carnahan, Chicago. Price 88 cents.

This book intended for use at the junior high school level fills a long-felt need for an authentic presentation of up-to-date astronomy in simple and direct language. Written over a period of four years with trials in several schools, it has already proved of great value, especially to teachers of general science. Ten units cover the study of the stars, the sun and the solar system. The author's drawings of Halley's Comet in 1910 add interest to the subject of comets while meteors are discussed in a most thorough and interest-

ing manner in keeping with his wide experience in this field in which he is an authority. The unit, "Time and the Calendar," stresses the work of the Naval Observatory on whose staff Dr. Wylie once served.

Outstanding features of the book are the sub-titles which emphasize in a sentence each topic discussed, the series of review questions at the end of each unit, the frequent references to mythological characters and the fine sketches of many of them, the stories of the astronomical origin of many symbols and expressions still in use, the glossary called "My Dictionary," the calendar of predictable events for 1939–1942 inclusive, and simplified charts for observation. Splendid photographs of the Naval Observatory, the moon, meteors, star fields, clusters and nebulae are reproduced.

The questions, "Why study astronomy?" and "What's the use of astronomy?" are answered from the junior's point of view.

ROBERT L. PRICE

Biology, by George William Hunter, Lecturer in Methods of Science Teaching, Department of Education, Claremont Colleges; Herbert Eugene Walter, Professor of Biology, Brown University; and George William Hunter, III, Assistant Professor of Biology, Wesleyan University. Cloth. Pages x+670. 14×22 cm. 1937. American Book Company, 360 North Michigan Avenue, Chicago, Ill. Price $3.75.

During the past five years there has issued from the publishing houses a steady stream of textbooks on general biology for college students. No two of these agree on the sequence of topics, although there is more or less agreement in content. In those in which ecology is discussed at all it is usually near the end of the book; this book is unique in opening with a chapter on ecology. The next three chapters deal with geographic distribution, mutual relationships, and classification; and with the first chapter, constitute the first unit "Natural History." There are undoubtedly certain advantages in the ecological approach to the study of biology. Natural history was probably one of the first phases of biology to interest primitive man, and it is one of the first to attract the interest of modern man in his early years—when he is not denied the privilege of observing nature. The authors do not give us their reasons for opening with ecology, but they state that it has been tried out for several years at Wesleyan University. It will be interesting to see whether this method of approach becomes popular elsewhere.

The book consists of twenty-seven chapters grouped under the following unit titles: "Natural History," "Fundamentals of Structure and Function," "Organisms Illustrating Biological Principles," "The Maintenance of the Individual," "The Maintenance of Species," "The Changing World," and "Man as a Conqueror." The last unit includes chapters on the economic importance of plants and animals, conservation, the control of disease, and eugenics.

The authors make no recommendation as to laboratory work, but their inclusion of detailed chapters such as that on the earthworm indicates that they may have such work in mind. Most of the text, however, seems well adapted to the lecture-discussion-demonstration type of course which has been growing in favor recently.

This is one of the best written and most interesting books on general biology that has come the reviewer's way in recent years. The authors are far from being beginners; they inform us in the preface that they have been teaching biology for a total of ninety-four academic years, in addition to over sixty seasons in summer field work. As most biologists know, they have had ample previous experience as textbook writers. These elements no doubt are important in explaining the maturity and accuracy of the

book. A careful sampling of numerous chapters has failed to disclose any errors.

The book is well illustrated, although in the opinion of the reviewer many of the figures should have been drawn on a larger scale in order to improve legibility. Most of the drawings are either original or redrawn. Lists of suggested readings are appended to the chapters. There is an index. This book is recommended for careful consideration by biology teachers.

EDWARD C. COLIN

Emotion and the Educative Process, A Report of the Committee on the Relation of the Emotion to the Educative Process, by Daniel A. Prescott, Ed.D., Chairman, Professor of Education, Rutgers University. American Council on Education, 744 Jackson Place, Washington, D. C. 1938. Cloth, 323 pp. $1.50.

As noted in the title, this book is a report of a special committee selected by the chairman of the Problems and Plans Committee of the American Council of Education to make a general exploratory study of the field of emotion and the educative process. The composition of the committee is in itself a guarantee of the value of this report. The report was written by the chairman, Daniel A. Prescott, to insure an integration not possible where many views were concerned. His ability to utilize the rich contributions furnished him by the members of the committee is evident from a reading of the report.

At the outset the committee found that the term "emotion" as used by the psychologists was too narrow and selected the term "affective experience" as more suitable because it covered the three aspects of experience studied—feelings, emotions, and all attitudes with emotional components. These basic affective phenomena are fully treated in the second chapter. While the evidence there presented is somewhat controversial the author thinks that there is no doubt as to its "enormous importance for education." In chapter three the data in reference to the physiological basis of affect is given. The conclusions reached are that the "emotions are among the most basic, deeply-rooted and biologically useful forms of behavior."

One cannot fail to be profoundly impressed by the discussion in chapters four, five and six on the trainability of affective behavior and its relation to maturity and personality needs and frustrations. One realizes that the older theories which contended that emotional behavior was entirely instinctive and therefore little subject to change must give place to the more positive objectives in education, namely, furnishing the child with wholesome affective experiences to enable him to develop attitudes which will make for a fuller and richer life. No longer may it be said that the "problem" child is the expression of bad heredity and mental deficiency.

In chapter seven on affective behavior and society the author calls attention to the function of education of so dealing with social situations as to develop in the youth common attitudes toward them in order to insure social stability and progress. This he believes can be done to better advantage if the youth are "habituated in the use of a scientific methodology in thinking about social problems."

Having pointed out the nature of affective experiences and their physiological basis it remained to show their influence upon the learning process and those aspects of education most needing special study. This the author does very admirably in the remaining chapters of the book. From the data here presented there is no doubt of the desirability of having satisfactory accompaniments to all aspects of the learning process. "Adequate motiva-

tion is essential to genuine learning." A proper recognition of the significance of different intensities of feeling in the learner while he is in a learning situation is also of major importance and until teachers and administrators fully realize this the results they hope to obtain will be barren.

We may conclude by agreeing with the author when he says that the major objective of educators is to "bring children to an optimum development of their personalities in our culture." The writer believes that there is no more thought-provoking book for educators to be found on the market today than this one and desires to recommend it to all those who are sincerely interested in the advancement of their profession and the enrichment of their own experiences.

FRED H. OTTMAN

Modern-School Geometry, by John R. Clark, The Lincoln School of Teachers College, Columbia University: Rolland R. Smith, Specialist in Mathematics, Public Schools, Springfield, Massachusetts: in cooperation with Raleigh Schorling, Head of the Department of Mathematics, The University High School and Professor of Education, University of Michigan. Cloth. Pages xiv+450. 12.5×20.5 cm. 1938. World Book Company, Yonkers-on-Hudson, New York. Price $1.36.

The unusual feature of this book is the insertion of reviews involving the skills and concepts of arithmetic and algebra throughout the text and the extensive use of algebra in geometric proofs and exercises. Notable among these uses are those in connection with angle measurement and the intersection of loci. Included also are several pages on solid geometry, a chapter on numerical trigonometry and a concluding chapter containing an introduction to analytic geometry and logic.

As in all the better modern geometry texts, particular emphasis is placed on developing logical thinking. There are 100 introductory pages before the first formal proof. In these pages, there is developed an understanding of hypothesis and conclusion, acceptable reasons for proof, as well as formal deduction and valid conclusion. The authors avoid all proofs involving superposition by using as postulates, four statements concerning the congruence of triangles and one concerning the relation between a central angle and its intercepted arc. An extra postulate at the introduction of parallel lines permits them to delay the mention of indirect proof. This subject is very ably handled later in the book. The chapter on geometric constructions and that on locus are unusually fine. There is no mention of variables or limits even as supplementary material.

Teachers of geometry should be particularly interested in the integration of the subject of arithmetic, algebra and geometry in this book.

MARIE S. WILCOX

Statistical Methods Applied to Economics and Business, by Frederick Cecil Mills, Professor of Economics and Statistics, Columbia University. Revised. Cloth. Pages xix+746. 15×22.5×4 cm. 1938. Henry Holt and Company, New York. Price $3.75.

This new edition of a work which has long been recognized as excellent in its field attempts to present not only the fundamentals needed by the beginning student, but also reference material for the working statistician. For this reason any attempt to use the book as a text in a first year course will require very careful selection of material. If this selection is made, however, the student will have available much more than the customary brief treatment. If the treatment is considered too detailed for an introductory course, there is certainly no question regarding the worth of the

book for reference material even in a beginning course. As an example of the material not found in many texts, one might mention the derivation of the formula for the coefficient of rank correlation. The tables in the appendix are more extensive than in many texts.

No attempt is made to provide a list of problems for solution by the student; such material would have to be supplied from other sources.

The treatment of the subject of correlation varies from the customary method in a manner which should emphasize the meaning of correlation.

A few trivial items seem to depart from accepted practice. It seems rather inconsistent to consider quartiles and deciles under the heading of averages. Reference to measures of skewness could very easily fail to discover a measure of skewness based on moments. It might be preferable on page 23 to indicate that it is only when the decimal portion of a logarithm is positive that it is called the mantissa.

Each chapter is followed by an excellent list of references treating the subject of the chapter.

CECIL B. READ

Drill Book in Plane Geometry, by Robert Remington Goff, Formerly Director of Mathematics, Senior High School, New Britain, Connecticut, and revised by Mildred Gardner Weld, Chairman of Mathematics, Senior High School, New Britain, Connecticut. Cloth. Pages vi+180. 13.5×19.5 cm. 1937. The Palmer Company, Boston, Mass.

This drill book is a comprehensive and thorough piece of work. To increase the emphasis on analysis, classification, and determination of method in geometry is the primary purpose of the authors.

The propositions are arranged according to their conclusions, which in turn determine the method of proof. The student is constantly aware of what he is doing. He understands the basic principles in each method; he acquires confidence and derives pleasure in accomplishments.

The important features of the book as given in the author's preface are as follows:

1. The propositions are arranged in groups, each group with a single purpose.
2. Summaries of methods in each group.
3. Model proofs.
4. Notes that answer the questions and give suggestions for proofs.
5. It is especially adapted for reviews and can be used with any text book.

The book is divided into four main sections, namely, straight-lines, circles, proportion and areas. The various propositions and topics are included under the above sections.

In addition the authors have included, 128 miscellaneous exercises, 45 types of college examination questions, 15 pages of model proofs, and 21 pages of notes on the various chapters. Furthermore, a page of symbols and abbreviations, a summary of methods, and a section of definitions are included.

Teachers and students of geometry will find this drill book very necessary to a better understanding of the field.

HYMEN D. SILVERMAN

Mathematics in Life, by Raleigh Schorling, Head of Department of Mathematics, The University High School and Professor of Education, University of Michigan, and John R. Clark, The Lincoln School, Teachers College, Columbia University. Cloth. Pages x+437. 15×24 cm. 1937. World Book Company, Yonkers-on-Hudson, New York, N. Y. Price $1.40.

This book is designed for the high school pupil who under the guidance of the school, is in need of a final year's work in mathematics. It has been written particularly for the non-mathematically-minded pupils who are "lost" in a rigorous formal course of mathematics.

The following features of the book are worth listing:

1. The organization of the subject-matter or "units."
2. The understanding of simple concepts and fundamental principles, rather than the laborious and methodical drills employed in solving problems.
3. Special attention is given to improving reading habits by the provision of comprehension exercises; (see unit 1) which are short and simple.
4. The provision of a series of instructional tests for pupils who lack a good foundation in "Arithmetic skills."
5. The abundance of illustrative materials, the clear, large type, and the arrangement of the materials.

The contents of the book by units are as follows: (1) Measurement, (2) Constructions, (3) Drawing to Scale, (4) Per Cents, (5) Use of graphs, (6) Wise use of Money, (7) Home and business Arithmetic, (8) Formulas and Equations.

Each unit contains, inventory and practice tests, and final tests on the unit. Furthermore, the answers to the tests, a record of progress for the pupil, tables for references, and an index are included.

Teachers of mathematics will find that this book is the answer to their problem . . . "What to do with the slow pupils?"

Hymen D. Silverman

RED-SHIFT PUZZLES ASTRONOMERS

Is the universe expanding, or does light get tired and lose energy in its race through space? These are the questions posed by "the red shift," that spectroscopic puzzle which is keeping the pencils of astronomers poised over paper in their endeavor to fathom its meaning.

When the apparent radial velocities of distant nebulae are measured, all but our local group seem to be receding from us, the more distant ones going faster, some at the rate of 26,000 miles per second. Actually no velocity is measured; what is observed is that the spectral lines due to the elements composing the star are shifted from their normal positions, and the more distant the nebulae the greater the shift.

The remarkable fact is that without exception these shifts are toward the red end of the spectrum, and if interpreted as motion indicate a movement away from us. If the distant nebulae are receding at these speeds the assumption is that the universe is expanding.

Dr. Edwin Hubble, of Mt. Wilson Observatory, puts the matter this way, red shifts increase with distance—the relation is linear—that is, red shifts are equal to distances times a certain constant. The relation was first established about five years ago from observations by Doctor Slipher at Lowell Observatory. Since that the list of spectra has been more than trebled by Doctor Humason, using the large reflectors on Mt. Wilson combined with the very fast spectrographic lens developed by Dr. W. B. Rayton, of Bausch & Lomb Optical Co.

Out to 150 million light years, the red shifts increase at a uniform rate. The significance of this strange characteristic of our sample of the universe depends upon the interpretation of red shifts. The phenomena may be

described in several equivalent ways—the light is redder, the light waves are longer, the vibrations are slower, the light quanta have lost energy.

Many ways of producing such shifts are known, but only one will produce large red shifts without introducing other effects which should be conspicuous but which actually are not found. This one explanation is that of rapid motion away from the observer. Red shifts are thus due either to actual motion or to some hitherto unrecognized principle of physics.

Hubble, however, is open-minded. At the moment he favors the concept of a stationary universe, but results do not rule out the possibility of an expanding universe. An analysis of several thousand nebulae whose distances and whose real luminosities are known indicates that they are all of the same order of luminosity, averaging about 80 million times as bright as the sun.

Says Hubble, "If the loss in energy occurs in the nebulae, then, very probably, red shifts are the familiar velocity shifts and the nebulae are all receding. If the loss occurs in space, then the nebulae are sensibly stationary, but light loses energy, by some unknown mechanism, in proportion to the distance it travels through the universe."

"I believe the 200-inch reflector will definitely answer the question of the interpretation of red shifts," says Hubble, "whether or not they represent actual motions—if the universe is expanding—and the 200-inch may indicate the particular type of expansion."
